# TROPICAL AGRICULTURE

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THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

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*TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, 14, Trinity Square, London, E.C. 3, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.*

## THE COLLEGE HONOURED.

THE news of the knighthood conferred on the Principal will be received with much satisfaction. Not only is it a fitting tribute to the capable administration which Sir Geoffrey Evans has exercised in College affairs during the past eight years but it is also a further mark of recognition by His Majesty's Government of the work of this Institution. The College has already been signally recognised by the Crown, for in 1926 it was incorporated by Royal Charter and in 1927, pursuant to that Charter it received the Gracious Patronage of His Majesty the King. Such recognition can have but one meaning: it expresses a definite appreciation of the importance of the College and of its increasing significance in the scheme of British Colonial development. Not without pride the College may claim that it exists for very laudable objects and that it has indeed achieved something towards their attainment. Year by year its influence is extending not only in the Empire but in other parts of the world also. Although from the outset it has primarily been concerned with the agricultural problems of the West Indies, with the passage of time and the assumption of an Imperial status it has considerably widened its sphere of activity. Similarly, to meet the needs of West Indian agriculture and also of the Colonial Agricultural Service, its training facilities have been suitably adapted. Still more recently it has opened its doors to Dominion and foreign students. Actually it is the only institution of its kind in the British tropics which trains candidates for the Colonial Agricultural Service. Although disappointments and difficulties have been encountered the development of the College has been singularly uninterrupted. To-day its position in the tropics is assured, both in the realms of agricultural research and education. Credit for this happy state of affairs must be given to the many distinguished personalities who have been and are still concerned with its welfare, to the various Colonial Governments and Bodies who have contributed so generously towards its upkeep and last, but not least, to its present Principal and Staff.

Beginning in 1927 Sir Geoffrey's régime has been marked by many beneficial changes and much progress. It has witnessed the completion of the extensive building programme commenced by Dr. Leake, the erection of many new buildings including the Low Temperature Station, the Power House, the New Chemical Block, the Agricultural Field Office, the Plant Quarantine

Station and the New Staff Quarters. The establishment of an Advisory Department of Agriculture and of related services in the Leeward and Windward Islands in the place of the old Imperial Department; the inauguration of the Low Temperature and Cacao Research Schemes; the continuation of banana breeding experiments; the further study of the froghopper pest and of allied problems relating to sugar-cane, including local soil conditions and the use of artificial fertilisers; the investigation of the soils of Tobago, Grenada, the Montserrat district of Trinidad, Antigua and Jamaica; the collection of much useful data on the economic aspects of the cacao and sugar-cane industries; the amplification of library facilities and the publication of numerous research papers and memoirs; in all of these, not to mention other cognate subjects, the impartial observer cannot fail to note the fruits of a more than successful period of constructive administration.

On the training side the curriculum of both Post-Graduate and Diploma courses has been considerably revised while additional educational facilities in the form of refresher and certificate courses have been provided.

Two Conferences have been held. One of these was a Conference of West Indian Agricultural Officers and the other a Cotton Conference. At the former, particular attention was devoted to the possibilities of establishing a fruit and vegetable industry in the British West Indies: already the extensive developments which have taken place testify to the usefulness of the initial resolutions adopted.

Although all too brief, this survey conveys a fair impression of the work undertaken and developments inaugurated since Sir Geoffrey Evans' appointment as Principal. To say the least it is an encouraging and hopeful record, and provided adequate support is forthcoming in the future there is no reason why these activities should not be extended with important results both to science and agriculture.

Sir Geoffrey's unremitting efforts on behalf of the College are widely known. Among his Staff the initiative and energy which he has invariably displayed in matters relevant to the several departmental activities, and to touch on a more intimate note, the geniality characteristic of his social and personal contacts have made him a trusted and popular leader. The honour so happily bestowed on him at this time is therefore all the more appreciated and it is hoped that the many good works in which he has so largely participated will bear fruit while he is still with us.

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THE subscription to *Tropical Agriculture* is six shillings per annum, post free, Trinidad currency, to all countries within the British Empire or seven shillings and sixpence, post free, Trinidad currency, to all other countries. Subscriptions can commence at any time during the year.

## ORIGIN OF AGRICULTURE.

IN a paper by N. J. Vavilov on "the problems of the origin of the world's agriculture in the light of the latest investigations" the author distinguishes seven primary centres of the origin of cultivated plants and thinks that these can be identified with seven corresponding foci of independent development of world agriculture. The characteristics of these centres are given in turn, indicating the grounds for considering them autonomous. It is shown further how the wealth of world species is largely concentrated in relatively restricted areas, mostly lying within the mountainous tropics and sub-tropics.—(*Plant Breeding Abstracts*, Vol. III, No. 2.)

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## PRACTICAL SEED SELECTION OF COCONUTS.*

Seed selection in coconuts has always to contend with cross pollination and consequent hybridization, since under normal conditions the coconut seldom selfs, and there is at present no adequate available supply of seed coconuts of pure strain. Suggestions for efficient seed selection under existing estate conditions are made. The chosen area should contain a large number of palms yielding well above the average, when the chances of cross fertilization with a high yielding parent will be probable, and a close examination should be made of individual palms which will at least ensure a good female stock. Only palms bearing 100 nuts or more should be selected as possible parents. All ripe nuts from these palms are collected and one typical specimen from each is examined for wet weight of wet meat. On a selected high yielding area of 80 acres carrying 3,875 palms, 17.8 per cent. bore 100 nuts and over. Thus the average of high grade palms in even a very high yielding area is very small and mass seed collection from such area is unsound. Of the 3,875 palms examined only 6 per cent. gave 100 nuts of 500 grammes or more of wet meat, and 500 grammes is the lowest advisable standard for seed selection. The shape or colour of the nut appeared, contrary to general belief, to have no influence on the meat content. Germination trials in November and February showed that average sized nuts gave slightly better germination and stronger plants than large nuts. The germination in both trials was 60 per cent. of good plants after 4½ to 5 months. Thus 80-90 per cent. of seed in excees of requirements should be laid down. The author considers that by these methods of selection the potential yield should be in the region of 20 piculs† of copra per acre, whereas at present even 15 piculs of copra per acre is deemed extraordinary.—(*Imperial Agricultural Bureaux, Hort. Abs.*, Vol. III, No. 3, Ab. 409.)

* By A. C. Smith, *Malayan Agricultural Journal*, Vol. XXI, No. 6, 1933.

† 1 picul=133⅓ lb.

# PRELIMINARY OBSERVATIONS ON THE STORAGE OF AVOCADO PEARS.

BY

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## Introduction.

THE preliminary investigations recorded in this paper were undertaken with a view to fostering the export of avocado pears from various West Indian Islands to northern markets (Canada and the United States of America) and if possible to Great Britain. From time to time in the past, various small consignments have been shipped to Canada, but no constant measure of success has so far been achieved. Not infrequently, indeed, the wastage is said to have been excessive. The fact that some consignments have arrived in good condition, however, indicates that given a suitable class of fruit and adequate knowledge and control of storage conditions, it should be possible to build up an export trade using this valuable commodity.

As no exact information was available regarding the cause or causes of wastage in exported fruit—whether due to bacterial or fungal activity, premature ripening during transport, over-refrigeration or atmospheric vitiation in the holds—these first storage trials were intended to break new ground. The conclusions drawn are, accordingly, entirely of a preliminary nature.

The fact that research funds only became available towards the end of the Trinidad avocado season has, unfortunately, caused these storage trials to be rather abbreviated. Consequently, although a considerable body of information has been collected, it is not proposed at this stage to attempt specific recommendations for the development of an export trade. At the same time, the records submitted afford some idea of the behaviour exhibited by a range of local varieties when stored under different controlled conditions. It is hoped that this work will prepare the way for more precise experimentation and for supervised trial shipments.

## Previous Investigations.

According to Condit (1), Mexican avocado varieties, cultivated in California, kept well for one month in cold storage but subsequently deteriorated through shrivelling and decay. The Challenge variety was stored satisfactorily at 32°F. for 6 weeks. Condit noted that softening took place more rapidly in fruit held at 36°F. than at 32°F.

Overholser (7), dealing with avocados grown in California, found that a temperature of 40°F. was satisfactory for all varieties tested except the Fuerte which required 45°F. to prevent blackening of the skin. In general a temperature of 32°F. was too low as it led to discolouration of the flesh, though indications were obtained that some varieties might be satisfactorily held at 32°-35.6°F. Under proper storage conditions some varieties could be kept for approximately two months, others for five to six weeks, and others for four weeks. Quick storage after harvesting and care in handling improved the keeping quality of fruits. Fruits picked just before commencement of softening kept best and attained excellent quality.

As early as 1907 Higgins (5) in Honolulu referred to the successful export of avocados in cold storage to San Francisco (approximately 7 days) with subsequent distribution by rail. More recently Harrold (4) found that Hawaiian avocados may be stored green at 36°F. for 6-8 weeks, thereafter ripening satisfactorily in 2-5 days.

Edwards and Guerrero (2) have described trial shipments of avocados between Guam, Marianne Islands, and Manila. The fruit, held at 40°F. during the voyage of 16 days, was discharged in good condition.

Precise records dealing with West Indian varieties are scanty. Shill (8) has briefly described experiments with small lots of fruit held at 45°-50°F. in Dominica with subsequent removal to tropical temperatures (average 85°F.). After being held in cold storage from 6-10 days, the fruit, on exposure to the higher temperatures, ripened up with such rapidity as to make for considerable loss, internal blackening being a characteristic feature.

## Types available in Trinidad.

Some doubt exists as to the original distribution of the avocado. It is thought to be native to tropical America from Peru to Mexico and not truly wild in the West Indies. Having been introduced at an early date, however, it is now to be encountered everywhere and is evidently thoroughly naturalised. Taking a general survey of this fruit from southern Brazil through the West Indies and Central America to Florida and California it is apparent that it is represented by a very considerable range of types. Some of the better varieties have been selected and named and by budding and grafting have been propagated as fixed types. Intercrossing apparently takes place readily. As seedling plants are seldom true to type, many different types and qualities of fruit are, as a result, to be encountered in the unnamed trees distributed throughout the Islands.

In the present work, only one named variety, the Pollock, was available for storage trials. Altogether, however, samples, in moderate quantities from 30-100 fruits per tree, were obtained from 33 different trees. This selection included dark green, pale green and purple pears, smooth and rough skinned fruits, adherent and loose-stoned fruits, and a range in shape from sub-spherical to bottle-necked. In short, apart from the fact that experiments were commenced

rather late in the season, the work was based on a range of materials sufficiently extensive as to afford a fair estimate of the storage qualities of West Indian avocados.*

In an interesting paper on Trinidad avocados, Freeman (3) has called attention to the need for selecting and propagating good varieties. Working on a collection of locally grown trees, he found that the average weight of one fruit varied from 7 oz. in a poor tree to 28 oz. in a good tree, with a general average weight of 14 oz. for the several trees examined. The weight of the stone varied from $1\frac{1}{2}$ to $4\frac{1}{4}$ oz. When the weight of the stone was worked out as a percentage of the total weight of the fruit, his figures show a range varying from 14.6 per cent. to 42.5 per cent., with an average of 29.5 per cent., Table 1.

**Table 1.**

SHOWING VARIATION IN WEIGHT OF FRUIT AND PROPORTION OF STONE IN SOME TRINIDAD AVOCADOS. (AFTER W. G. FREEMAN.)

| No. | Source. | Weight single fruit. | Percentage—Single Fruit by Weight. | |
|---|---|---|---|---|
| | | | Stone. | Meat and Rind. |
| | | lb. oz. | | |
| 1 | River Estate .. | 14 | 35 | 65 |
| 2 | Do. .. | 7 | 30 | 70 |
| 3 | Do. .. | 10 | 40 | 60 |
| 4 | Do. .. | 1 1 | 24.1 | 75.9 |
| 5 | Do. .. | 13 | 37.5 | 62.5 |
| 6 | Do. .. | 1 0 | 27.3 | 72.7 |
| 7 | Do. .. | 13 | 16.6 | 83.4 |
| 8 | Do. .. | 1 0 | 42.5 | 57.5 |
| 9 | Do. .. | 1 5 | 29.7 | 70.3 |
| 10 | Do. .. | 9 | 29.1 | 70.9 |
| 11 | Do. .. | 15 | 27.2 | 72.8 |
| 12 | Do. .. | 11 | 25.0 | 75.0 |
| 13 | Do. .. | 7 | 31.8 | 68.2 |
| 14 | Do. .. | 1 12 | 14.6 | 85.4 |
| 15 | Mrs. Stollmeyer's Diego Martin | 1 0 | 22.9 | 77.1 |
| 16 | Do. .. | 1 3 | 16.6 | 83.4 |
| 17 | Do. .. | 14 | 20.4 | 79.6 |
| 18 | Do. .. | 1 2 | 27.8 | 72.2 |
| 19 | Garden, Govt. Botanist, R. B. G. .. | 1 4 | 21.8 | 78.2 |
| 20 | Do. .. | 1 7 | 18.4 | 81.6 |

In general, varieties for export should have an adherent stone of relatively small size, compact flesh of good flavour and free from fibres and a skin sufficiently thick to withstand normal handling. As to colour, shape and size, current opinion favours a green fruit, typically round, oval or pear-shaped and of medium size, *i.e.*, such as may be packed with ease in standard crates. As the industry develops, however, it may be anticipated that departures from these standards would be permissible in fruit of special quality. The Pollock, for example, a pear of good keeping quality and among the best produced in Trinidad, is rather too large for the standard pack.

Fig. 1 illustrates the general types of fruit used in the present experiment. Determinations of weights of fruit and stone, and percentage weight of stone for the varieties used, cover a range comparable with that indicated in Freeman's Table.

As a food the avocado is mainly valuable for its comparatively high fat content. In Californian fruit this may vary from 9.8 to 29.1 per cent., with an average of 20.1 per cent. Freeman has pointed out, however, that avocados grown in Trinidad, and presumably elsewhere under moist tropical conditions, contain considerably less oil than those grown in California and Florida. Of Trinidad fruits which have been analysed, the richest contained only 7.6 per cent. of oil, a figure which lies below the minimum obtained from Californian varieties. Introduced as well as local varieties are also characterised by low oil content. From these data and also from the fact that West Indian and Guatemalan varieties are definitely less cold-resistant than Mexican varieties* in the field (6, 9), it may be anticipated that, in the matter of storage behaviour, West Indian fruit may exhibit not inconsiderable departures from the results obtained elsewhere.

## Methods and Materials.

Standardised methods were adopted throughout. As the genetic constitution of local avocados is very variable, it cannot be assumed that any two trees are quite alike. Accordingly, for experimental purposes, the fruits from each tree—from 30 to 100 according to the material available—were recorded throughout as one consignment. These were sub-divided and held (i) naked and (ii) wrapped in grease-proof paper and packed with a small quantity of wood-wool or coconut fibre in standard crates, at 80°F. (average tropical temperature), 70°F., 53°F., 45°F. and 40°F. Fruits were picked with the help of clippers or "bag-picked" wherever possible, usually at such a stage of maturity as to permit of ripening at tropical temperatures in the course of 3 to 6 days—a stage of maturity (just prior to softening), regarded as suitable by the Trade. Varieties at first green but becoming purple at maturity were used in experiments where a close comparison of ripening was required, the degree of colouration affording a useful criterion. Altogether, fruit from some 33 different trees was used in these trials.

*Thanks are due to Mr. E. J. Wortley, O.B.E., Director of Agriculture and to Mr. C. Connell for supplies of fruit.

* "The West Indian race is much too tender for planting in California with the exception of a few well-favoured localities, and even there has rarely produced satisfactory fruits. Studies on the relative freezing points of the cell sap of the different races show that the sap of this race freezes at higher temperatures than do those of the Guatemalan and Mexican varieties. Of these two the Guatemalan is the tenderer." (6).

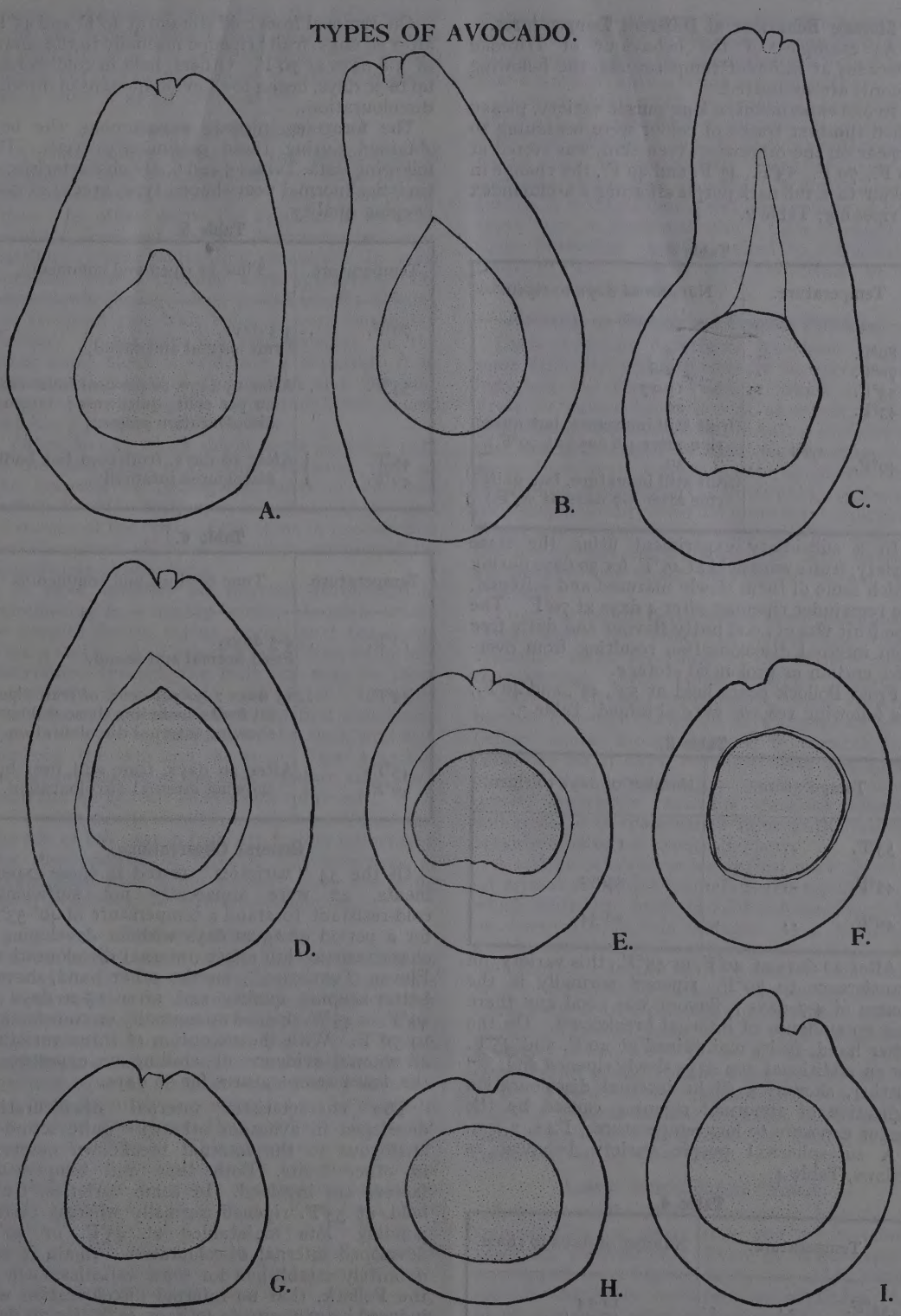



**Fig. 1.** A. Pollock; B. Long Purple, Semi-Bottle-necked; C. Bottle-necked, Green; D.E.F. Pears with loose-stone; G. Subspherical Green; H. Subspherical Purple; I. Common Pear-shaped Fruit: (Semi-diagrammatic, ½ Natural Size.)

**Storage Behaviour at Different Temperatures.**

As examples of the behaviour of Trinidad avocados at different temperatures, the following records are submitted.

In one experiment, a long purple variety, picked when the first traces of colour were beginning to appear on the otherwise green skin, was stored at 80°F., 70°F., 53°F., 45°F. and 40°F., the change in colour to a full dark purple affording a useful index of ripening, Table 2.

**Table 2.**

| Temperature. | Number of days to ripen. |
|---|---|
| 80°F. .. | 5 |
| 70°F. .. | 6-8 |
| 53°F. .. | 15-17 |
| 45°F. .. | 20 (fruit still immature, but quite ripe after 4-6 days at 70°F.). |
| 40°F. .. | 20 (fruit still immature, but quite ripe after 5-7 days at 70°F.). |

In a subsidiary experiment using the same variety, fruits were held at 45°F. for 30 days during which some of them slowly matured and softened, the remainder ripening after 4 days at 70°F. The ripe fruit was of good nutty flavour and quite free from internal discolouration resulting from over-refrigeration or prolonged storage.

From Pollock pears held at 53°, 45°, and 40°F., the following records were obtained, Table 3.

**Table 3.**

| Temperature. | Number of days to ripen. |
|---|---|
| 53°F. .. .. | 15-18 |
| 45°F. .. .. | 25-30 |
| 40°F. .. .. | 28-34 |

After 20 days at 40°F. or 45°F., this variety, on transference to 70°F., ripened normally in the course of 4-7 days; flavour was good and there was no evidence of internal breakdown. On the other hand, fruits maintained at 40°F. and 45°F. for an additional ten days slowly ripened and, on cutting, showed a slight internal discolouration indicative of abnormal ripening caused by the longer exposure to low temperatures, Figs. 2 & 3.

A sub-spherical purple variety behaved as follows, Table 4.

**Table 4.**

| Temperature. | Number of days to ripen. |
|---|---|
| 53°F. .. .. | 12-14 |
| 45°F. .. .. | 28-30+ |
| 40°F. .. .. | 30+ |

On removal from cold storage at 40°F. and 45°F. after 20 days, fruits ripened normally in the course of 5-8 days at 70°F. Others, held in cold storage up to 30 days, began to show slight signs of internal discolouration.

The foregoing records were among the best obtained during these preliminary trials. The following data, Tables 5 and 6, are characteristic of varieties (normal pear-shaped type, green) of poor keeping quality.

**Table 5.**

| Temperature. | Time to ripen and comments. |
|---|---|
| 70°F. .. | 3-5 days. Fruit normal and sound. |
| 53°F. .. | After 15 days, 80 per cent. over-ripe, 20 per cent. quite ripe; internal discolouration present. |
| 45°F. } 40°F. } | After 20 days, fruit firm but badly discoloured internally. |

**Table 6.**

| Temperature. | Time to ripen and comments. |
|---|---|
| 70°F. .. | 4-5 days. Fruit normal and sound. |
| 53°F. .. | 15 days: 50 per cent. of fruit ripe; all fruits, including those still hard showing internal discolouration. |
| 45°F. } 40°F. } | After 20 days, fruit still firm but showing internal discolouration. |

**General Observations.**

Of the 33 "varieties" tested in these experiments, 22 were apparently not sufficiently cold-resistant to stand a temperature of 40°-53°F. for a period of 15-20 days without developing a characteristic chill effect (internal discolouration). Eleven "varieties", on the other hand, showed better keeping quality and after 15-20 days at 40°F. or 45°F. ripened up normally on transference to 70°F. With the exception of three varieties, all showed evidence of chilling on exposure to the lower temperatures for 30 days.

The characteristic internal discolouration developed in avocados otherwise quite sound is analogous to the internal breakdown observed in other fruits. Both time and temperature factors are involved. In some varieties, fruits held at 53°F. ripened normally whereas corresponding lots maintained at 45°F. or 40°F. developed internal discolouration. Again it was definitely established for some varieties, such as the Pollock, that no internal discolouration was induced by exposure to 40°F. or 45°F. for 20 days whereas during the following 10 days slight abnormal changes gradually developed. More

precise information regarding the influence of time and temperature factors on the production of chill effects is not available from these experiments, but will be the subject of detailed research when fruit is again obtainable.

**Nature of Chilling.**

A contributory factor in the production of chilling is that avocados held at comparatively low temperatures, even at 40°F., slowly continue to ripen. In other words the application of refrigeration does not induce dormancy but only partially retards maturation processes. In some varieties normal ripening may apparently take place slowly during a long period in cold storage, the resultant ripe fruit being of very fine nutty flavour. In varieties less cold-resistant, on the other hand, there is evidently a departure from the normal course of metabolism and the fruit pulp, as a result, acquires an unusual brown colour and has a peculiar bitter flavour.

Other factors which might have played a part in the production of internal browning, such as the presence of pathogenic fungi or bacteria, carbon dioxide vitiation, over-ripeness at the time of storage or the effect of the stone in loose-stoned varieties, have all been definitely eliminated by appropriate observations.

In most varieties the internal discolouration, culminating in a muddy-brown, chocolate-brown or purplish-brown colour, begins next the stone, Figs. 4 and 5. As a rule it is not at first uniformly distributed through the fruit but may be more intensively developed in one sector. In other varieties, such as the Pollock, the first discolouration makes its appearance in the flesh mid-way between the skin and the stone, Figs. 3 and 4. Actual breakdown of the flesh does not take place until the whole fruit has become quite soft.

To what extent locality, weather conditions and the use of late season fruit are factors influencing the development of internal discolouration in cold-storage fruit is not known: they are being noted as subjects for future investigation.

**Practical Inferences.**

Even at this early stage, and particularly in view of the failures experienced in trial shipments of local varieties, certain practical inferences cannot be overlooked. Compared with Californian fruit, it is evident that the constitution of West Indian varieties is such as to render them very much less resistant to cold. Critical temperatures have not yet been definitely ascertained, but for many of the typical local fruits they evidently lie in the region of 50°-60°F. This temperature, however, is not considered sufficiently low for overseas transport, since it permits of complete maturation in the course of 12 to 15 days. Even for a short transport period of 8 to 10 days, the factor of safety is inadequate, since the fruit rapidly becomes over-ripe on transference to a higher temperature. If these observations are confirmed during subsequent trials it follows that many varieties, though of good quality and useful for local consumption, may prove unsuitable for an export industry. It is possible that this inference may be overturned by experience in handling next year's crop, but in the meantime the writer feels that a word of caution is not out of place here.

Though this defect in genetical constitution rules out a considerable number of varieties, otherwise suitable, a number of types still remain which may be successfully exported even to comparatively distant markets. In future investigations it is hoped that a still larger range of local types may be examined with a view to selecting those possessing qualities suited to refrigerated transport and subsequently permitting of an adequate distribution period.

**Maturity on Picking and Cognate Problems.**

Until sufficient experience has been gained, some difficulty will undoubtedly be encountered regarding the correct stage at which to pick. Fruit for local consumption is, as a rule, picked just before it begins to soften. As it is undesirable that soft fruit should be crated for export, and as some time may elapse before adequate local pre-cooling or cooling in the ship's holds is effected, fruit should be full grown but quite firm on picking. Where a more prolonged storage period is required, the use of less mature fruit will have obvious advantages, but exact information is not yet available.

From the records derived from these preliminary experiments, the effect of pre-storage delay evidently varies according to the variety under consideration. After being kept for only 2 to 3 days at tropical temperature, some varieties became over-ripe during 20 days storage at 45°F. Others, again, though exposed to tropical temperatures for 6 days, remained firm and sound at 45°F. for approximately 30 days. In short, precise knowledge regarding standard varieties will again be of the greatest value in the rational organisation of an export industry.

A serious defect recorded against some varieties on arrival at distant markets is the rapidity with which quite firm fruits become soft and over-ripe on removal from cold storage. As a result the fruit becomes useless for retailing unless disposed of immediately. In the writer's opinion this defect may be referable to varietal constitution, storage conditions, or to a combination of both. Among Trinidad varieties, some showed rapid breakdown whereas others, after 15 to 20 days at 45°F., remained in sound condition for 7 to 10 days at 70°F. A view has been expressed that red-skinned fruits in general become over-ripe more quickly than green ones: this, however, has not been confirmed during these trials.

**Loss in weight during Storage.**

Loss in weight during storage is referable to transpiration or desiccation and to metabolic processes (respiration). Even in fruit exposed unwrapped to refrigeration by the cold-air-blast system, the losses sustained are negligible, *e.g.*, about 4 per cent. after 20 days at 40°F. At higher temperatures loss in weight proceeds more rapidly, Fig. 6.

Fruit of large and medium sizes, held at temperatures of 70°F. and 45°F. and at relative humidities of 100 per cent. and 50 per cent. gave the losses in weight shown in Table 7.

**Table 7.**

| Nature of Sample. | Temperature °F. | Relative Humidity per cent. | Percentage loss in weight after | | | |
|---|---|---|---|---|---|---|
| | | | 1 day.* | 6 days. | 12 days. | 16 days. |
| Medium-size fruit .. .. | 45 | 100 | 0.8 | 1.3 | — | 1.5 |
| | | 50 | 0.8 | 2.3 | — | 4.3 |
| | 70 | 100 | 0.9 | 2.7 | † | — |
| | | 50 | 0.7 | 3.8 | † | — |
| Large-size fruit .. .. | 45 | 100 | 0.8 | — | — | 1.1 |
| | | 50 | 0.8 | — | — | 3.6 |
| | 70 | 100 | 0.8 | — | 2.7‡ | — |
| | | 50 | 0.9 | — | 4.5‡ | — |

* Fruit exposed to tropical temperatures for 1 day. † Fungal wastage. ‡ Fruit quite ripe.

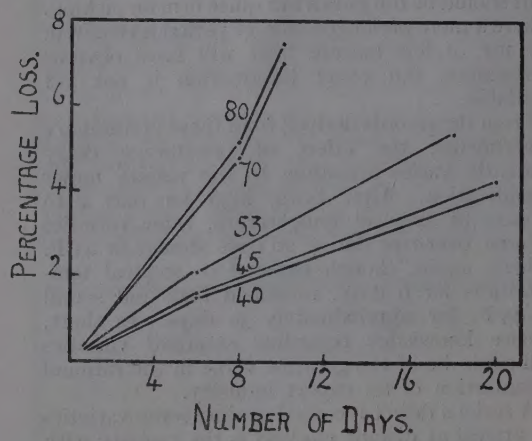



Fig. 6. Percentage loss in weight at different temperatures.

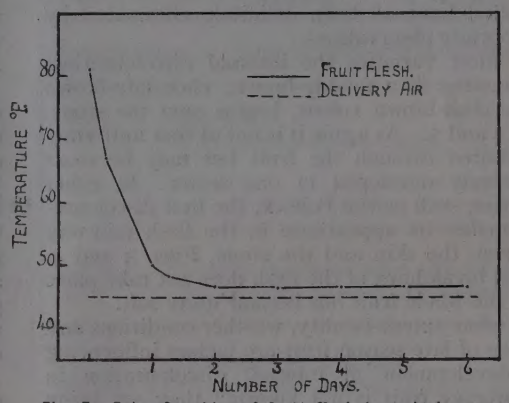



Fig. 7. Rate of cooling of fruit flesh in a single exposed crate, when delivery-air temperature was 45°F.

From these and other data it seems unlikely that loss in weight will be a factor making for serious wastage in the refrigerated transport of this fruit.

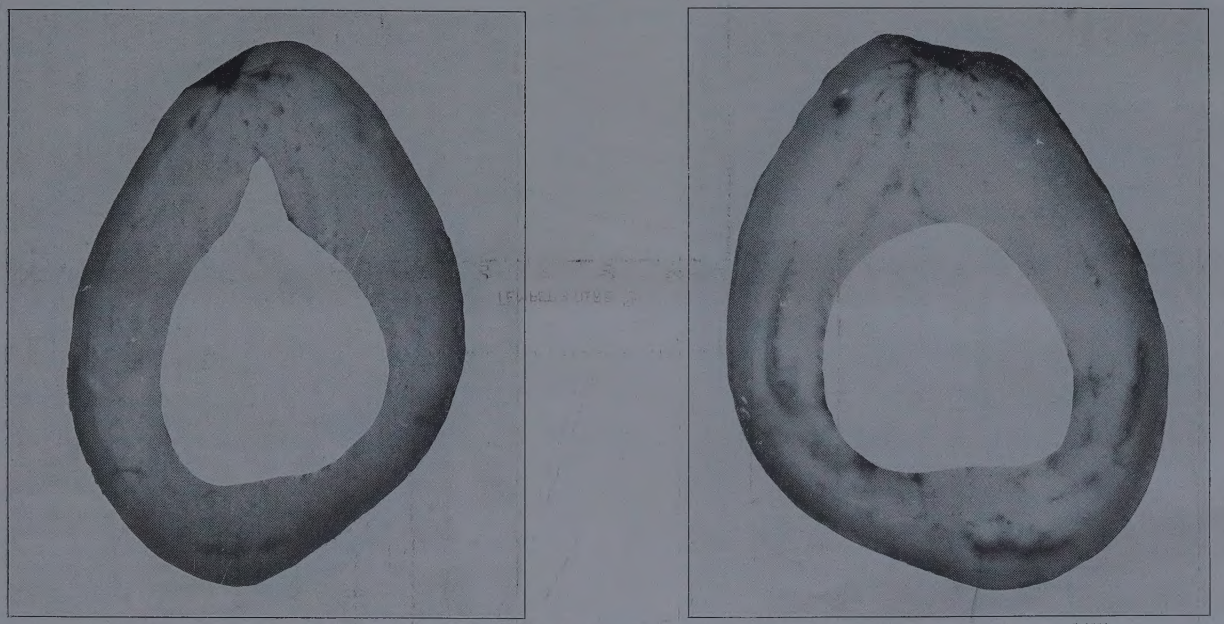
**Rate of Cooling in Packs.**

In view of the fact that avocados may ripen comparatively quickly at temperatures in the vicinity of 50°F., it was important that some approximate idea of the rate of cooling in crated fruit should be obtained.

In a preliminary experiment single crates were used: the fruits were wrapped in grease-proof paper and lightly packed in wood-wool or coconut fibre; a thermometer was then inserted deeply into the flesh of one of the innermost fruits: the crates were then placed side by side on a bench fully exposed to the cold-air-blast and the temperature read at intervals. Characteristic average readings for two crates placed side by side are illustrated in Fig. 7. It is to be noted that, in the course of six days, the temperature of the fruit-flesh, even in a single exposed crate, was not quite reduced to the air temperature of the room.

In a second experiment, twenty-four crates of fruit were placed together against the wall of the storage chamber so as to form a solid block of four tiers, *i.e.*, resembling a small portion of a cargo stack. The crates, supplied with dunnage, were placed so as to permit of the maximum air circulation. In two of the innermost crates thermometers were inserted into the fruit-flesh. Tubes for drawing off gas samples were also placed in the crates. The rates of cooling, in rooms maintained at 45°F. and 40°F. respectively, of the fruit flesh in such non-marginal crates are illustrated graphically in Figs. 8 and 9.

## STORAGE OF AVOCADO PEARS.



FIGS. 2 and 3 :—*Early stages in the development of internal discolouration in the Pollock variety due to chilling.*
(*Photograph by F. W. Urich.*)

## STORAGE OF AVOCADO PEARS.

FIGS. 4 and 5 :—*Later stages in the production of internal discolouration through chilling in an unnamed variety.*
(*Photograph by F. W. Urich.*)

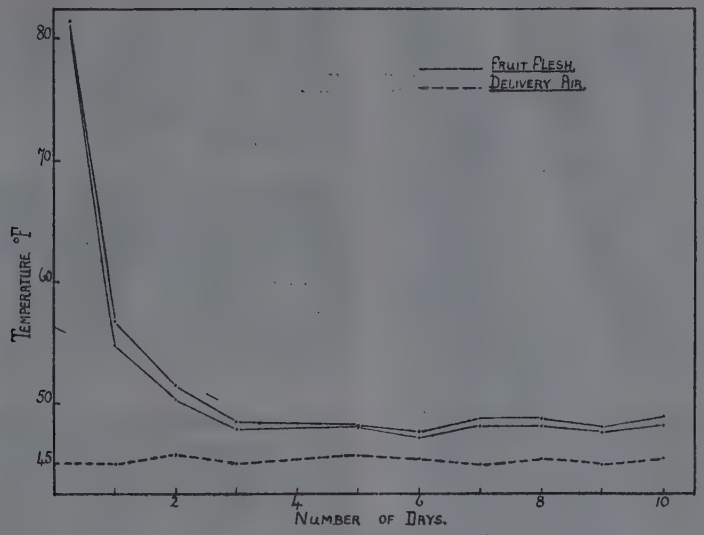



Fig. 8. Rate of cooling of fruit flesh in a stack of crates, when delivery air temperature was maintained at 45°F. approximately.

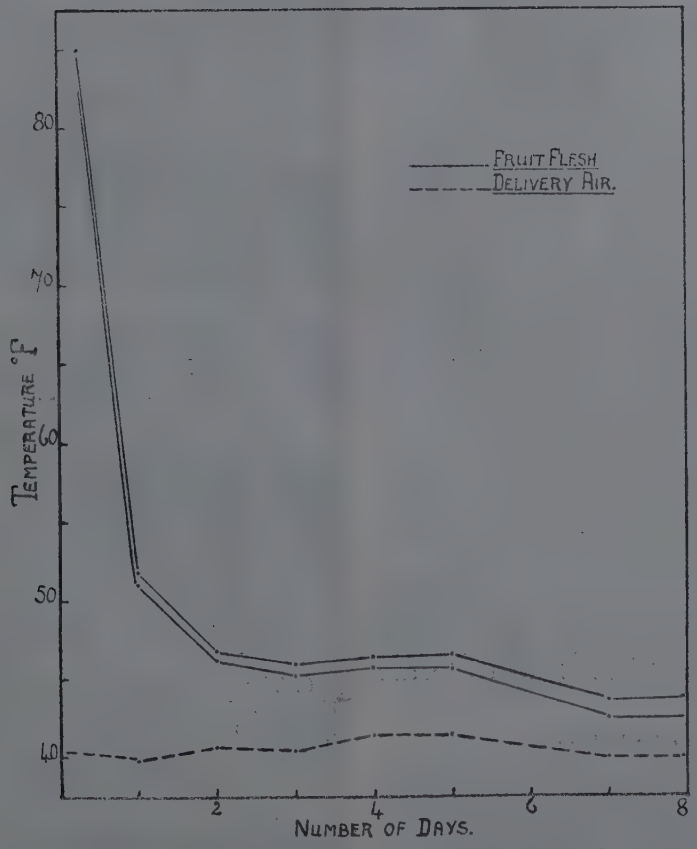



Fig. 9. Rate of cooling of fruit flesh in a stack of crates, when delivery air temperature was maintained at 40°F. approximately.

In both instances it will be observed that in the course of 8-10 days the fruit flesh was not brought down to the temperature of the room. Gas analyses, on the other hand, showed only 0.07-0.16 per cent. of $CO_2$, indicating that the cold air had free access to the packs. The phenomenon of self-heating in fruits is well known. The fact that avocados continue to ripen, even at the lower temperatures employed in these investigations, probably explains why cooling approximately to the temperature of the room could not be achieved.

This lag in the cooling of packs has certain important practical aspects. Where large bulk consignments are being handled, it may be anticipated that the inner, non-marginal crates will be at a temperature considerably higher (at least 5°F.) than that of the circulating air, with concomitant increase in the rate of ripening. In the longer voyages this would in some instances undoubtedly lead to wastage through over-ripeness. Control of this factor will depend on a precise knowledge of the temperature requirements of standard varieties and on adequate provision being made for the circulation of cold air throughout the cargo.

### Respiration and Gas Storage.

In dealing with a commodity such as the avocado, wastage during transport is not infrequently referred by the layman to $CO_2$ vitiation in the holds. Detailed results are not yet available, but data accumulated during these investigations indicate that a normal accumulation of $CO_2$ in the storage chamber is not likely to rank as a cause of wastage. Thus when different quantities of fruit were placed in large sealed desiccators and maintained at different temperatures, the percentage of $CO_2$ rose to upwards of 15 per cent. in the course of 15 days without causing either external scalding or internal discolouration or breakdown. The flavour of the fruit on ripening was good and the storage life prolonged. Where the concentration of $CO_2$ was allowed to rise above 20 per cent., the fruit after a time became superficially scalded and the pulp acquired a uniform, leathery brown appearance. The latter was not quite comparable with the discolouration induced by chilling. Fruits subjected to high concentrations of $CO_2$ subsequently proved much more susceptible to fungal activity.

In general, in view of the lack of adequate cold-resistance in many West Indian varieties, the writer has formed the opinion, stated provisionally, that this fruit would probably lend itself to preservation by a combination of refrigeration and gas-storage methods.

### Fungal Wastage.

Wastage in fruit ripened at tropical temperatures is largely due to anthracnose, *Colletotrichum gloeosporioides* Penz. In cold storage fruit, on the other hand, while some spots and blemished areas yielded this fungus, much of the wastage, in the form of stem-end rot, spreading spots, blemishes and soft rots, could be referred to *Botryodiplodia theobromae* Pat. Wounded areas characteristically became infected with *Penicillium expansum* Link emend Thom. *Fusarium* and *Phomopsis* spp. were occasionally isolated in conjunction with *B. theobromae*.

Purple varieties on the whole appeared to be less affected by storage diseases than green varieties, some of the latter being very subject to anthracnose and soft-rots in general. Fruits held at 40°F. and 45°F. and ripened up at 70°F. in the course of 5-7 days did not suffer at all severely through fungal wastage, the principal cause of rejection throughout these investigations being internal discolouration resulting from chilling.

### Summary and Conclusions.

1. An account is given of preliminary investigations into the storage behaviour of avocado pears with a view to fostering an export industry from West Indian Islands to northern and British markets. Trial shipments made in the past have not met with a constant measure of success: in many instances extensive wastage has been the rule.

2. Investigations conducted elsewhere, chiefly in California, indicate that this fruit can be held at low temperatures (40°F. or lower) for considerable periods without undue loss. In view of the rather different genetical constitution of Trinidad varieties, growth conditions, &c., it was not anticipated that comparable records would be obtained.

3. In all, fruits from 33 different trees—each treated as a separate lot—were used. This selection included dark green, pale green and purple pears, smooth and rough skinned fruits, adherent and loose-stoned fruits and a range in shape from sub-spherical to bottle-necked.

4. An account is given of the storage behaviour of the several varieties at the following temperatures 80°F. (average tropical temperature), 70°F., 53°F., 45°F. and 40°F.

5. Even at 40°F., fruit slowly ripens during storage. Of the 33 varieties used 22 were apparently not sufficiently cold-resistant to stand a temperature of 40°-53°F. for a period of 15-20 days without developing a characteristic internal discolouration. The remaining 11 varieties ripened normally at 70°F. after 15-20 days at 40°F. or 45°F. With the exception of three varieties, all showed traces of internal discolouration when maintained at 40°F. or 45°F. for 30 days.

6. The internal discolouration repeatedly observed is regarded as a direct result of over-refrigeration or chilling. It is, in fact, a physiological disease, comparable with the internal breakdown sometimes observed in other fruits.

7. Other factors to which attention has been directed include the maturity at which to pick, cognate problems, and loss in weight during storage.

8. Observations on the rate of cooling in packs indicate a considerable lag between fruit-flesh temperature and that of the circulating cold air. This may have important bearings where large bulk consignments are concerned.

9. Wastage through vitiation in the holds is not likely to be a serious difficulty in handling this commodity, since it can apparently stand relatively high concentrations of $CO_2$ without sustaining external or internal damage. In general it is thought that this fruit should lend itself to preservation by gas-storage methods in conjunction with refrigeration.

10. Fungal wastage in stored fruit has been very slight, *Botryodiplodia theobromae* and *Colletotrichum gloeosporioides* being the principal fungi isolated from stem-end rot, spots, blemishes and soft rots.

**References.**


1. Condit, I. J.—*Californian Exp. Sta. Rept.*, 1919.
2. Edwards, C. W. & Guerrero, J.: *Guam Exp. Sta. Rept.*, 1930.
3. Freeman, W. G.—The Avocado in Trinidad and Tobago. *Bull. Dept. Agric. Trinidad and Tobago*, Vol. XVIII, 3, 1919.
4. Harold, E. V.—*Hawaiian Agric. Exp. Sta. Rept.*, 1930.
5. Higgins, J. E.—Marketing Hawaiian Fruits. *Bull.* No. 14, *Hawaiian Agric. Exp. Sta.*, 1907.
6. Hodgson, R. W.—The California Avocado Industry. *Circ.* 43, *California Agric. Extension Service*, Univ. of California, 1930.
7. Overholser, E. L.—Cold Storage Behaviour of Avocados. *California Avocado Assoc. Ann. Rept.*, 1924-25.
8. Shill, A. C.—*Report of the Marketing Officer 1931-32 for Leeward and Windward Islands, B.W.I.* Trinidad Govt. Printers, 1932.
9. Stahl, A. L.—Changes in Composition of Florida Avocados in Relation to Maturity. *Bull.* 259, *Univ. of Florida, Agric. Expt. Sta.*, 1933.


## SOIL EROSION.

[An Abstract of Technical Communication No. 28, by T. Eden, M.SC., A.I.C., published by the *Imperial Bureau of Soil Science.*]

The extent of damage due to erosion is difficult to gauge, but in many countries the financial loss from this cause is comparable to that from disease. Although much money is spent on research and propaganda on disease, little or no notice is taken of losses due to erosion, notwithstanding the fact that loss of fertility from erosion is more or less permanent. Valuable soil is lost from agricultural lands, but it does not necessarily follow that the deposits of run-off water in subsiding floods provide equally valuable materials.

At one time the effect of cover, particularly tree cover, was regarded as being entirely confined to the interception, of beating rain, and this idea still holds sway to a certain extent, particularly in tropical countries where shade trees are grown in association with crops. Gorsse pointed out as early as 1879 that, whilst interception of rain and re-evaporation before it reaches the ground plays a small part, it is the water-holding capacity of forest litter which provides the major protection against floods. He assesses the water capacity of litter as eight times that of soil. Lowdermilk suggests that, apart from its water-retaining capacity, litter fulfils a further important function, namely that of preventing the silting-up of pore space by the washing down of the finer fractions. Supposing that such a silted up layer forms immediately below the surface of a bare soil, its effect would be that of a filter, and it would determine almost completely the rate of percolation through the subsequent layers.

The effect of cultivation has not been studied by exact measurements. Certain workers such as Lowdermilk consider that cultivation is one of the most important agencies in inducing accelerated erosion, and this is supported by general evidence; but others recommend deep tillage since this gives additional pore space and percolation. One observation is recorded where two inches of rain was held by loose soil produced by 10 inch cultivation. On the other hand, the effect of soil type has been investigated in detail by Bennett. He found that the ratio of silica to sesquioxides of aluminium and iron is the distinguishing characteristic, the critical ratio being 2. Soils with higher ratios were found to be generally plastic and erosive, while those with lower ratios were friable and non-erosive. If this theory is applied to tropical soils, these will generally fall into the non-erosive class, and it is remarkable that where climatic conditions are most favourable for erosion, the nature of the soil formed is a comparatively non-erosive type.

The preventative measures employed in combating soil erosion vary according to the crops, climates and situations. The general principles are encouragement of ground cover, levelling of sites, and construction of barriers to break the velocity of run-off water. The retention of ground cover, litter, and mulch offer the best solution to erosion difficulties particularly under highly developed systems of estate agriculture with perennial crops such as rubber, coffee, tea and cocoa. Used in conjunction with rough terracing, bunding and contour planting, either of the crop itself or of supplementary bush green manures, a very complete degree of protection is assured. The natural bias in favour of clean-weeding is slowly breaking down, and the present world economic conditions have done much to discourage the practice.

D. W. D.

# ENTOMOLOGY AND AGRICULTURE IN THE BRITISH SOLOMON ISLANDS.

By

R. J. A. W. Lever, B.Sc. (Dunelm.), D.I.C. (Lond.), A.I.C.T.A. (Trinidad), F.L.S., F.R.E.S.

The British Solomon Islands Protectorate forms a portion of Melanesia and lies some five hundred miles to the east of New Guinea to which it was once united. The latitude is between 5° and 12° 30′ S.

The annual rainfall averages 120 inches but varies from half to more than twice this amount; the relative atmospheric humidity is 92 per cent. and the maximum shade temperature 93°F.

As there is a large variety of parent rocks (including volcanic tuffs, andesite, diorite, gabbro, dolerite and limestone), there is an equally assorted range of soil-types from red (so-called "lateritic") clays to coralline sands, loams and alluvium.

The six largest islands are clad with dense jungles to their summits which on Guadaleanal rise to 8,000 feet though extensive grass plains and downs of coralline limestone also occur on this and one other island. Raised coral beaches are found inland.

The chief export from the Protectorate is copra of which some 21,000 tons are exported annually. The fruit of the strictly indigenous ivory nut (*Coelococcus salomonensis*) and timber from the Santa Cruz Kaui pine (*Agathis macrophylla*) and "Island cedar" (*Calophyllum* sp.) are of minor importance. Rubber, cotton and bananas were once cultivated and rice and maize are still grown for local use.

Economic entomology is reduced to pests of the coconut palm and domestic cattle.

The pioneer work in agricultural entomology was done by Froggatt (1) and Tothill (2) the former suspecting, and the latter apparently proving, that puncturing of the fruit-branches by *Axiagastus campbelli* Dist. was the chief cause of immature nutfall. This Pentatomid is parasitised by two local Hymenoptera, the Eupelmid *Anastatus axiagasti*, Ferr.(3) and the smaller Scelionid *Micrephanurus painei* Ferr., the latter is the more abundant and easier to rear experimentally. The red tree ant (*Oecophylla smaragdina* F.) is a very efficient predator of the nymphal and adult *Axiagastus* but is killed off by two other ants, viz.: *Iridomyrmex myemioidea* Emery and *Pheidole oceanica* Mayr.

Another pest is the Pyralid *Tirathaba rufivena* Walk., a moth which ranges from Ceylon to New Caledonia and, if the so-called *T. trichogramma* Mayr. is only a geographical race, is found as far afield as Fiji, Tonga and Samoa. The damage is done by the larvae which eat into the young nuts, especially two to three weeks after the bursting of the spathe. The favourite food, however, and that on which they develop quickest, is the male flowers. A new host-plant was found by the author in the swamp palm, *Nipa fruticans* Thunb. where the parasitism of the older caterpillars by the Braconid *Apanteles tirathabae* Wilk. is higher than on the coconut palm (4). The last named insect is itself parasitised to a small extent by the Perilampid *Calliceras fijiensis* Ferr. first recorded from Taveuni, Fiji (3).

The adult is nocturnal and the female only is phototropic to artificial light. Mating is apparently impossible unless there is abundant room for flight, hence large breeding cages are necessary.

As the life-cycle averages one month, fresh generations appear more or less simultaneously with new spadices of the palm though all stages are actually present in any given tree, being the progeny of other moths.

Besides fruit-pests there are also two harmful insects on the leaves; both are Hispid beetles. *Brontispa froggatti* Sharp, which is the more serious, damages the unopened leaves by scarifying the surfaces of adjacent "fronds" which have to be treated with a mixture of soap and tobacco juice. All stages are to be found in this site which, although apparently a concealed ecological niche, nevertheless allows the minute *Trichogrammatoidea nana*, Zehnt. to oviposit in the eggs. Also there is a small red Gamasid mite *Celaenopsis* sp. in association with the adult. It is hoped to introduce from the Netherlands East Indies a species of *Tetrastichodes* as a pupal parasite. The beetle has been found by the author on a wild palm, *Ptychosperma* sp., which seems to be a new host-plant.

The other Hispid, *Promecotheca opacicollis* Gestro, was taken by me in June, 1933, in the Santa Cruz Islands which appears to be the first record of its occurrence in the South Seas outside of the New Hebrides. The damage it does differs from that of *Brontispa* in that it is intrapinnal as opposed to interpinnal, *Promecotheca* larvae mining between the epidermes of a single pinna ("frond") and not between two leaves. It has two parasites in the three largest islands of the Santa Cruz Group, viz.: the Trichogrammatid *Oligosita utilis* Kow, (3) and the Eulophid *Closterocerus splendens Kow.* The eggs are laid in batches of three to five under a conical mound of chewed leaf-tissue. It is hoped that the pest may be prevented from spreading to the Solomon Islands proper to the westward by prohibiting transport of palm leaves from Santa Cruz.

The only primary pest of stock in the Group is the buffalo-fly *Lyperosia exigua* de Meij. which was probably introduced from New Britain about 1923. Pure bred zebu cattle are somewhat more resistant to the attacks of this fly than shorthorns or hybrids between the two. The wounds are made by the rasping mouth-parts and are intensified by visits from *Musca vicina* Macq., the local house-fly. A small colony of the Pteromalid *Spalangia cameroni* Perkins, sent from Fiji, whence it was introduced from Hawaii in 1928, was liberated by me on Guadalcanal. However, as this parasite is somewhat catholic

in its choice of hosts it is hoped that a large consignment of a hybrid between the male Javan *S. sundaica* and the female Australian *S. orientalis* may shortly be introduced.

Entomology from the medical viewpoint is chiefly concerned with the only species of anopheline mosquito present in the Group. This is *Anopheles* (*Myzomyia*) *punctulatus* Dön. which lays its eggs in temporary accumulations of water such as collect in hoof-marks and cart-tracks. Except in native villages the percentage of infected mosquitoes is generally low which is peculiarly fortunate as the screening of bathrooms with wire gauze is still the exception rather than the rule, a fact noted by Paine (5) in 1929. Some filariasis occurs but much less abundantly and manifestly than in Polynesia where, however, the same vector *Aëdes variegatus* Dol. is suspect. Buxton(6) gives a reference to the variety *tongae* being found in Sikaiana Island whence it must have been introduced in canoes from Tonga (Friendly Islands) by migrant Polynesians.

So far as the cultural side is concerned it must be stated that no continuous cultivation or manuring is practised even on estates which have been planted 20 or more years. Sporadic attempts at disc-ploughing or hoeing have been made from time to time and salt water, rotten coral and burnt copra have all been applied so that the pathological side at least has not been neglected.

The present low price of South Sea Islands copra has not been conducive to outlay on estate practices and now that these are needed most they can be afforded least. One company has recently decided to embark on a series of manurial experiments which ought to give most valuable results by the end of two years.

Several sites have been but indifferently suited for growing coconuts. Former grassy plains with heavy soil and only sixty inches of annual rain in some years provide anything but a good environment. Where this is intensified by heavy undergrowths of *Mimosa pudica* (never ploughed under), *Sida rhombifolia L.* or spear-grass (*Chrysopogon aciculatum*) with or without lalang (*Imperata arundinacea*) and bracken, it is not to be wondered at if there is more than a normal or physiological nutfall which even in a good environment amounts to 65 to 75 per cent. of female flowers produced. Besides faulty physical conditions there is often a scarcity of available plant-nutrients (lime. potash, phosphate and magnesium), so that poor yields, or even barren trees are not scarce.

**References.**

(1) Froggatt, W. W., 1911.—"Pest and Diseases of the Coconut Palm". Sydney. Dept. Agric., N.S.W.

(2) Tothill, J. D., 1929.—"Reconnaissance Survey of Agricultural Conditions in the British Solomons Protectorate". Fiji.

(3) Ferrière, Ch., 1933.—*Stylops*. Vol. 2. Parts 4 and 5.

(4) Lever, R. J. A. W., 1933.—*British Solomon Islands Agricultural Gazette*, Vol. I. No. 3.

(5) Paine, R. W. (and Edwards), 1929.—*Bull. Ent. Res.* XX. Part 3.

(6) Buxton, P. A. (and Hopkins), 1927.—London School of Hygiene and Trop. Med. *Mem.* No. 1.

## COFFEE CULTIVATION.

### Further observations on factors in Arabica coffee culture.

In this pamphlet (No. 8 of the Tanganyika Territory Department of Agriculture) F. R. Sanders and A. J. Wakefield describe and illustrate the root system of coffee. The best local coffee soil is a red volcanic, well aerated, with good nitrate content and containing, besides the usual mineral salts 50-60 per cent. of clay. A foot lower, with a marked pan at its junction, is an unaerated subsoil containing such mineral salts as potash, phosphates, lime, sulphur, magnesia, &c. The root system of the coffee consists of:—(1) An upper layer of laterals running parallel to the surface, extending to a radius of seven feet in a 4-year-old tree and plentifully endowed with fibrous rootlets. This section operates only in the aerated top soil, which has high nitrogen content. It is noticeable that while the feeding roots of these laterals point both upwards and downwards at a medium depth, those on laterals running lower than one foot only point upwards. (2) The second type of root is made up of laterals growing downwards into the unaerated subsoil which has a low nitrate content. It is thought that these roots are concerned with the supply of water and mineral salts and that the feeding rootlets they bear do not require an aerated soil for development. The development of the feeding rootlets in the soil surface proceeds in waves of growth and rest, which appear to coincide with the periodic rise and fall of the nitrate content of the soil, which in turn corresponds with the rainy seasons, *i.e.*, in the rainy season nitrification is low or absent owing to the waterlogging of the soil. In districts where the soil is deep, sandy and porous, and the rainfall high, nitrates are washed away before the roots have time to absorb them, and on these soils coffee will not succeed. Tea, on the other hand, with its deep root system, does well on these lands. At present, therefore, the limiting factor in coffee soils is the effect of rainfall on the soil nitrates. It is pointed out that this range could be extended by the production of a deeper rooting root-stock compatible with an arabica scion. Comparison is made with local conditions and those pertaining in temperate countries. It is shown that whereas in temperate climates the manufacture of carbohydrates is low and nitrates are plentiful, often necessitating some artificial restriction on their absorption, the reverse is the case under the strong sunlight of Tanganyika. Growers are warned that anything which will tend to diminish the power of the tree to absorb nitrogen, such as root pruning, damage to roots by cultivation, or the erosion of the nitrate-holding surface soil, must be avoided. A warning is given against deep planting which is particularly detrimental to the coffee tree.—(*Horticultural Abstracts*, Vol. III, No. 2, Ab. 238.)

# PREDICTION OF ASH PER CENT. IN FINAL MOLASSES FROM CONDUCTIVITY MEASUREMENTS AT 35°C.

BY

J. G. DAVIES.

[*The following note is a resumé of a paper which appeared in the "International Sugar Journal" (1933), Vol. XXXV, p. 472. This paper was the result of extensive work carried out at the College Department of Sugar Technology, in which the relationships between Chemical Ash determinations and conductivity measurements were studied.*]

IN this experiment an attempt has been made to establish a relationship between ash and conductivity measurements at 35°C. This temperature was chosen as the vast majority of cane sugar factories lie within the tropics, and because few control laboratory temperatures exceed it, while experience has shown that a small thermostat (5 litre beaker) can be maintained within ±0.5°C. with reasonable ease.

The procedure adopted was that of ZERBAN and SATTLER, who measured the conductivity of a molasses solution and then of three aliquots of this solution to which 0.25N-Hydrochloric acid, N-Orthophosphoric acid and 0.25N -Potassium Hydroxide had been added respectively The molasses solution consists of 0.5 grm. of molasses per 100 ml. solution, and 5 ml. of each of the electrolytes are added to 200 ml. of it.

They recommend that the electrolytes should be standardized by conductivity, using 5 ml. added to 200 ml. of conductivity water, and they record the values which they obtained at 20°C. In the experiment these electrolytes were accordingly made up and standardized conductometrically at 20°C. by adjusting this solution until the average of eight readings, four with each of two cells, corresponded with the values recorded by ZERBAN and SATTLER. The values are nett, that is the conductivity of the water has been deducted. After standardization at 20°C., a similar series of readings were obtained on the electrolytes at 35°C. and the values recorded as follows :—

**Conductivity at 20°C. and 35°C. of 5 ml. of Electrolytes added to 200 ml. conductivity water. (Nett values.)**

| | No. Readings. | Specific 20°C. | Conductivity 35°C. |
|---|---|---|---|
| 0.25N-HCl .. | 8 | 0.002370 | 0.002892 |
| N -Orthophosphoric acid .. | 8 | 0.001925 | 0.002223 |
| 0.25N - KOH .. | 8 | 0.001422 | 0.001783 |

Solutions of each of the 145 available samples of Final Molasses were then made up by dissolving 5.0 grms. of molasses in 1 litre of conductivity water and proceeding as described above. In this way four determinations were carried out on each sample. The cell constant was checked with N/50 Potassium chloride after every 16 determinations. The results of the conductivity measurements and of the chemically determined ash were then examined statistically.

The conductivity measurements are given in terms of specific conductivity × $10^6$, and K, $K_1$, $K_2$ and $K_3$ are used to denote the conductivity of the solution alone, and of 200 ml. of the solution plus 5 ml. of hydrochloric acid, of potassium hydroxide and of orthophosphoric acid in that order.

Multiple correlation coefficients were calculated for the entire data, for the data of each of the two countries represented by a sufficient number of samples, and for the data of each of five factories represented by a sufficient number of samples. A multiple correlation coefficient expresses the extent to which one variant (per cent. ash) depends upon, or is related to, the combined variation of other variants (K, $K_1$, $K_2$, $K_3$) and is therefore always positive. The method of calculating this coefficient is outlined by FISHER (1) and the significance can be tested by the "z" test. Further multiple correlation coefficients were calculated omitting $K_1$ and $K_1$ and $K_3$, for the same sets of data as above. See following table which also shows the correlation coefficient for ash and K.

| Ash and | Multiple Correlation Coefficients. | | | Correlation Coefficient K. |
|---|---|---|---|---|
| | K, $K_1$, $K_2$, $K_3$ | K, $K_2$, $K_3$ | K, $K_2$ | |
| All Samples | 0.89 | 0.89 | 0.89 | 0.88 |
| Country I .. | 0.93 | 0.90 | 0.90 | 0.69 |
| Country II .. | 0.85 | 0.85 | 0.85 | 0.84 |
| Factory A .. | 0.60 | 0.60 | 0.59 | 0.57 |
| Factory B .. | 0.74 | 0.73 | 0.71 | 0.69 |
| Factory C .. | 0.88 | 0.87 | 0.84 | 0.84 |
| Factory D .. | 0.95 | 0.91 | 0.91 | 0 91 |
| Factory E .. | 0.96 | 0.73 | 0.80 | 0.59 |

Considerable variation is exhibited in the values obtained for the different sets of data. In one or two individual cases it would appear possible to calculate a fairly reliable regression equation from the simple ash and conductivity (K) data alone, but it is to be noted that in all cases the highest value is obtained when all four conductivity readings are included. Partial regression coefficients and equations were therefore calculated (*see* FISHER (2)) for the four conductivity measurements and ash for the same sets of data as were used for the multiple correlation coefficients.

(1) *Statistical Methods for Research Workers*, 2nd Ed., p. 226.
(2) *Ibid*, p. 132.

**Partial Regression Equations.**

| | |
|---|---|
| All Samples | .. Per cent. Ash = $0.006788K - 0.001479K_1 + 0.003088K_2 + 0.001017K_3 - 0.585022$ |
| Country I | .. Per cent. Ash = $0.003939K - 0.003254K_1 + 0.003612K_2 + 0.000645K_3 + 4.683289$ |
| Country II | .. Per cent. Ash = $0.007037K - 0.000963K_1 + 0.001807K_2 + 0.001511K_3 - 0.776977$ |
| Factory A | .. Per cent. Ash = $0.005712K - 0.000848K_1 + 0.002734K_2 + 0.000940K_3 - 0.419626$ |
| Factory B | .. Per cent. Ash = $0.004412K - 0.001535K_1 + 0.002661K_2 - 0.002389K_3 + 8.782091$ |
| Factory C | .. Per cent. Ash = $0.005186K - 0.001269K_1 + 0.001369K_2 - 0.001626K_3 + 8.459696$ |
| Factory D | .. Per cent. Ash = $0.003080K - 0.007486K_1 + 0.004641K_2 + 0.003427K_3 + 7.470638$ |
| Factory E | .. Per cent. Ash = $0.001393K - 0.003139K_1 + 0.005593K_2 - 0.002087K_3 + 8.250013$ |

By the use of the equations so set up, each individual determination of chemical ash could be predicted by the equation derived from the entire data, while in certain cases, a second prediction could be calculated from the country formula and a third prediction by the factory formula. Variations in the composition of the ashes from the different factories and their reactions to the added electrolytes are demonstrated by the varying partial regression coefficients obtained. Factories A and C, for example, grind canes from adjoining lands, but the regression equations for these two factories show considerable differences.

The degree to which the predicted values of chemical ash agreed with the determined values was not so close as that found by LORGE, ZERBAN and SATTLER (3), and a possible explanation of this is that variation in composition of ash becomes more significant with the increased temperature at which the present conductivities were measured. A survey of these differences is shown in this Table.

**Differences between Predicted and Determined Values of Chemical Ash.**

| Error. | Percentage of Samples. | | |
|---|---|---|---|
| | By Overall Formula per cent. | By Country Formula per cent. | By Factory Formula per cent. |
| 0.00-0.20 .. | 29.0 | 37.7 | 63.3 |
| 0.21-0.40 .. | 27.6 | 23.2 | 18.3 |
| 0.41-0.60 .. | 20.6 | 13.8 | 16.7 |
| 0.61-0.80 .. | 8.3 | 12.3 | 1.7 |
| Above 0.80 .. | 14.5 | 13.0 | 0.0 |
| Total .. | 100.0 | 100.0 | 100.0 |

It is to be noted that as the formula used to calculate the predicted ash becomes more specific for the sample, the percentage with low error becomes greater, and the percentage with high error becomes smaller. Approximately 90 per cent. of the values predicted by the factory formulae lie within the limits of error of the chemical test; assuming, of course, that the chemical tests were in all cases exact.

In order to test the formulae established for three of the factories, 1933 samples of final molasses obtained from them were analysed chemically for per cent. ash, and the four necessary conductivity measurements were also carried out. The appropriate formula was then used to predict the per cent. chemical ash and the results were compared as follows :—

**Differences between Predicted and Determined per cent. Ash of samples not included in the calculated data. (By Factory Formula.)**

| Error. | Percentage. | |
|---|---|---|
| 0.00-0.20 .. | 34.4 | Within limits of error of Chemical test, 3 pts. in 50—80.3 per cent. |
| 0.21-0.40 .. | 32.8 | |
| 0.41-0.60 .. | 14.8 | |
| 0.61-0.80 .. | 11.5 | |
| Over 0.80 .. | 6.5 | |
| | 100.0 | |

| Crop, 1933. | Mean per cent. Ash. | |
|---|---|---|
| | Determined. | Predicted. |
| Factory A .. .. | 10.02 | 9.91 |
| Factory C .. .. | 9.14 | 9.11 |
| Factory D .. .. | 8.26 | 8.17 |

Approximately 80.3 per cent. of the predicted values lie within the permissible limits of error of the chemical method and considering that these samples were not included in the data used to calculate the formulae, a very fair agreement exists between the per cent. ash determined conductometrically and the value obtained by chemical analyses.

(3) *Ind. and Eng. Chem.* (Anal. Ed.), 1932, 4, p. 435.

# THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE[1].

By Sir Algernon Aspinall, C.M.G., C.B.E., B.A.
*Secretary of the Tropical Agricultural College Committee.*

To Sir Norman Lamont, the second baronet, is due the credit for having been the first to call attention to the need of an Agricultural College for the Colonies situated within the tropics.

In an article which appeared in the *Empire Review* as far back as 1902 he, then Mr. Lamont, sketched out the form which such a College might assume*. Read to-day, his suggestions seem to have been almost prophetic. He considered that the Imperial Department of Agriculture which had been founded by Mr. Joseph Chamberlain four years before, would form "an excellent nucleus for the College", which must be of university standing; that candidates for admission, who should not be less than seventeen years of age, should be required to pass a searching examination before admission and again at the close of each year's session, which should be of nine months' duration; and that there should be attached to the College an instructional sugar factory—all of which has come to pass. Developing his theme in 1913 at a meeting held under the auspices of the Liberal Colonial Club at the residence of Sir Robert Perks, M.P., he definitely suggested that the College should be in Trinidad and that the headquarters of the Imperial Department should be transferred to that island. He also stressed the great importance of research.

Another protagonist of the movement was Professor J. B. (now Sir John) Farmer, who declared in season and out of season that the College must not be a mere local institution, but must have a real scientific and research outlook and very high ideals.

It was not until after the War that the proposals for the establishment of a Tropical Agricultural College emerged from the discussion stage. Sir Francis Watts has already related in these pages how in accordance with the recommendations of a Committee set up in 1919 by Viscount Milner, then Secretary of State for the Colonies, with that eminent biologist and man of affairs Sir Arthur Shipley as Chairman, the West Indian Agricultural College was founded in Trinidad in 1921 and was thrown open to students in the following year†.

Pending the presentation of a petition to the King for a Royal Charter, the College was incorporated as a company "limited by guarantee". Sir Arthur Shipley was Chairman and Sir David Prain, then still the Director of the Royal Botanic Gardens, Kew, Vice-Chairman. Sir Francis Watts, the Commissioner of Agriculture for the West Indies, was the first Principal, and he and the members of his scientific staff who, with the headquarters of the Imperial Department of Agriculture, were transferred from Barbados to Trinidad, formed the Academic Board.

In selecting Trinidad as the site of the College the Tropical Agricultural College Committee were influenced by several advantages offered by that island. Foremost among these were complete immunity from hurricanes or cyclones, a wide variety of tropical products, and accessibility from the other West Indian islands and British Guiana as well as from England. There were also Trinidad's generous offers of land at St. Augustine, and a handsome contribution of £50,000 for building, to provide which the planters actually asked that they might be taxed. It should be recorded that, after the Committee had approved their Report, Jamaica made a similar offer conditional upon the Imperial Department being removed to that island*.

It is still sometimes asked why the College was located in the West Indies and why not in Ceylon or Malaya, for example. The reply is that as Lord Milner and Sir Arthur Shipley used to say, the College *had* to be placed *somewhere*, and experience has shown that its geographical position has not deterred students from entering it from Ceylon and even the distant Seychelles.

Prince Albert Victor and Prince George, now King George V, in their narrative of their cruise in H.M.S. *Bacchante* (1879-1882), after describing a visit they paid to the Maracas Fall in Trinidad, wrote: "On returning the views appeared finer than they did on going up . . . Just above San Josef . . . from the front of the Church . . . that plain looked in the low evening sunlight just like an English park with its grass, and large rounded trees standing here and there in the paddocks". Just over forty years later that park-like plain was selected by Mr. W. G. Freeman, then Director of Agriculture of Trinidad and Tobago, as the ideal site for the new College. On it have now risen residences, hostels, and laboratories grouped round about a stately building which accommodates the administration department and the library, while unobtrusively tucked away in one corner are the sugar factory, power house, gas plant, and low temperature station. The Principal occupies the old "great-house" of St. Augustine estate, and scrupulous care has

* "The West Indies: A Warning and a Way," by Norman Lamont. *The Empire Review*, Vol. IV, No. 19, August, 1902.

† "The Imperial College of Tropical Agriculture," by Sir Francis Watts. *The Empire Cotton Growing Review*, Vol. I, No. 1, January, 1924.

* Report of the Tropical Agricultural College Committee, presented to Parliament by command of His Majesty, February 1920. Command 562.

## IMPERIAL COLLEGE OF TROPICAL AGRICULTURE.

*Aerial view of the College showing Main Buildings (centre); Dining Hall (opposite rear Rugby post) and Milner Hostel (opposite farther Rugby post). Rear of Main Buildings, from left to right, Chemical Laboratory, Biological Laboratory, Quarantine Station, Power House, Low Temperature Station and Experimental Sugar Factory (further side).*

## ACADEMIC STAFF AND STUDENTS, 1933-34.

Sitting left to right:

*1st Row* :—C. W. Wardlaw, F. W. Urich, J. R. Dickson, E. E. Cheesman, H. R. Briton-Jones, Sir Geoffrey Evans, F. Hardy, R. C. Wood, A. W. Paterson, A. M. Adamson, P. E. Turner.

Standing left to right:

*1st Row* :—C. T. Watts, L. A. Corbin, W. A. Tansley, D. W. Duthie, E. E. Pyke, G. G. Gianetti, D. D. Paterson, A. K. Briant, N. Wright, J. G. Davies, R. E. D. Baker, F. J. Pound.

*2nd Row* :—E. W. Momber, J. D. Tallantire, R. A. Hamilton, J. R. Miller, R. F. A. L. Reed, R. J. M. Swynnerton, A. Garces, M. W. Gibbon, H. K. Ashby, G. K. Argles, C. G. Wigley, B. de B. Darwent, J. Cook, R. G. Fennah, W. F. Steven, J. M. S. Usher-Wilson.

*3rd Row* :—A. E. Tai, E. C. D. Green, R. D. E. Yearwood, S. Duncan, A. E. Wyatt, W. L. Lee, C. C. Seale, A. C. Suarez, H. P. Singh, H. B. Pidduck, W. R. C. Paul, V. O. Ferrer, St. G. Cooper, A. D. Herbert.

*4th Row* :—R. Depaz, A. Despointes, W. K. Mitchell, M. A. Thomas, A. C. Gomez, E. J. Hugh, R. S. Junor, M. S. Hassan, A. C. Robinson, H. M. James, C. Lai Fook, A. V. Wan Ping.

been taken to preserve the amenities of the site. The condition of the buildings, roads, lawns, and hedges is an object lesson of how real estate should be tended in the tropics.

Although the College began its existence as a West Indian institution, provision was made at the very outset for post-graduate study and research, and "refresher" courses for Agricultural Officers besides a three years' Diploma course. The Governing Body in their first Report declared that they had had constantly in view the desirability of establishing the College on the broadest Imperial basis so that it might provide for the needs not only of the British West Indian Colonies and British Guiana, but also of the tropical Colonies of the Empire generally. In 1923, in order to emphasize the Imperial nature of the undertaking, they changed the name of the College to "The Imperial College of Tropical Agriculture". Under that significant title it was incorporated by Royal Charter in 1926, receiving in the following year the gracious patronage of the King.

Meanwhile Sir Francis Watts, who had done so much toward founding the College, had retired in 1924 and had been succeeded by Dr. Hugh Martin Leake, Principal of the Agricultural College at Cawnpore, whose régime was marked by much valuable constructive work, including the planning of roads and additional buildings and an expansion of the curriculum.

In the first academic year there were eleven Diploma students and two post-graduates on the register. At the close of 1924 the corresponding numbers were eighteen and fourteen. They have since steadily increased, until this year there were fifty-two students in residence, of whom twenty-four were taking the Diploma Course, twenty-five the post-graduate course, and three special courses.

A turning-point in the history of the College was the appointment of a Committee in 1924 by Mr. J. H. Thomas, M.P., then Secretary of State for the Colonies, with Viscount Milner as Chairman, to enquire into and report upon the recruitment and the training of officers for the Agricultural Departments of the non-self-governing Dependencies. Since the War there had been a definite awakening to the potentialities of the Colonies, with their area of upwards of 2,000,000 square miles and their vast population of 50,000,000 souls, as a source of supply of essential foodstuffs and raw materials, and as a market for manufactured goods. Between 1905 and 1925 trade between the United Kingdom and the Colonies had been nearly quadrupled, but for the further development of agriculture scientific assistance was lacking, and there was grave difficulty in finding suitable candidates for the Colonial agricultural services.

Recognizing at once the seriousness of the shortage of botanists, entomologists, and mycologists, the Committee presented to the Secretary of State for the Colonies in March, 1925, a preliminary report in which they outlined a scheme for the provision of post-graduate scholarships to be granted annually to suitable applicants in order to create a pool from which the needs of the various Colonial Agricultural Departments might be met from year to year*. They recommended that these scholarships should normally be granted for two years, the first to be spent at institutions in this country and the second usually at the Imperial College of Tropical Agriculture, in order to give the scholars a practical introduction to systems of tropical agriculture on the spot.

These recommendations were approved by a great majority of the Colonial Governments invited to co-operate, and the Imperial Government consented to provide, over an experimental period of ten years, grants equivalent to one-third of the total contributions available. It is noteworthy, and indeed an historic fact, that in adopting this system the Government was following the lead of the Empire Cotton Growing Corporation, which, having similarly experienced difficulty in recruiting suitable officers for its research and development work, first sent out selected candidates for training at the Imperial College of Tropical Agriculture in 1922. Fifty-five students of the Corporation have already passed through the College and are now working in such widely scattered parts of the Empire as the Union of South Africa, Northern Rhodesia, Southern Rhodesia, Nyasaland, Uganda, Nigeria, the Gold Coast, the Sudan, Tanganyika, Trinidad, Jamaica and Ceylon.

It was not until three years later that the first Colonial Office students entered the College. No fewer than 120 have now passed through it and most of them have taken up appointments in the Colonial agricultural services. Never before can the report of a Committee have been more promptly or successfully implemented.

Since the Cotton Research Station was opened by the Empire Cotton Growing Corporation in 1926 it has been closely associated with the College. Dr. S. C. Harland and Dr. T. G. Mason, its two executive officers, had been for a short time members of the College Staff. Its research laboratories are within a stone's throw of those of St. Augustine and are provided with gas and electricity from the College plant. The liaison became closer in 1927, when on Dr. Leake's retirement Mr. Geoffrey Evans, who had been Director of Cotton Culture in Queensland under the Corporation since 1923, was appointed Principal, and, after the lamented passing of Sir Arthur Shipley, whose last illness was undoubtedly aggravated by anxiety and worry over the finances of the College, Sir James Currie, Director of the Corporation, became Chairman of the Governing Body of the Imperial College.

* Embodied in: Agricultural Research and Administration in Non-Self-Governing Dependencies. Report of a Committee appointed by the Secretary of State for the Colonies, Command Paper 2825. 1927.

All that is necessary in respect of investigations into cotton is performed at the Cotton Research Station, and long-range research at the College is confined to cacao, sugar-cane, bananas and citrus. Cacao research is financed by some of the leading manufacturers and the cacao-growing Colonies, and, for the present at any rate, banana research by the Empire Marketing Board, which provided funds for the erection and equipment of a modern low temperature plant. Side by side with this research, experiment work is being carried on with soils and fertilisers with the support of Imperial Chemical Industries, and each of the principal departments of the College—namely, those devoted to agriculture, botany and genetics, chemistry and soil science, economics, entomology, and mycology and bacteriology—is conscientiously working on various problems with the solution of which they are concerned. Each with one exception is under the charge of a professor (in the case of entomology a senior lecturer), who is assisted by a lecturer. Mention must also be made of the Department of Sanitation and Hygiene, the officer in charge of which imparts to the students a rudimentary knowledge of health in the tropics which not only proves of great value to the men themselves but also to the labourers under their control in the various parts of the world in which they are posted.

As Professor, now Sir John, Farmer has pointed out, there had existed a gap, largely unbridged, between the university at home and the work that awaited the agricultural officer in his district, where the conditions that embraced his problems and affected their solution were so widely different from those within the range of his previous experience. The College enables this hiatus to be short-circuited, and it is now possible for a man in a few months to build effectively on his previous knowledge of principles. In short, he is now in a position to obtain easily and under exceptionally favourable conditions just that kind of wide outlook over, and reasonably intimate familiarity with, the material and environment of his prospective problems so necessary for ultimately attacking them with good prospects of success. Then, to quote Sir Arthur Shipley, men of science are slowly but surely gaining control over the devastating forces of nature. To train them for the conquest they must have education. They must be taught what advances have been made by their predecessors, and what advances are being made by their contemporaries. Above all they must learn to observe accurately and to record faithfully what they have observed. Such training cannot be carried out at home and alone. It needs an institution like the Imperial College with its library, its laboratories, its experiment fields, and its staff of skilled professors and lecturers.

The College was visited by Mr. F. L. Engledow, now Draper's Professor of Agriculture at Cambridge University, in 1929, at the request of the Empire Marketing Board, and in 1932 by Mr. F. A. Stockdale, the Agricultural Adviser to the Secretary of State for the Colonies. Both were favourably impressed by what they saw, and the College received also the commendation of the Colonial Office Conference which met in London in 1930. A Committee of the Conference, of which Sir Herbert Stanley, then Governor of Ceylon, was Chairman, recorded their deep appreciation of the work being carried out, and placed on record their recognition of the importance of the Imperial College as the centre for post-graduate training in tropical agriculture for the agricultural services of the Colonial Empire. In their report on the organization of a unified Colonial Agricultural Service they recommended that membership of the service should be confined in future to candidates who had received not less than two years' training, or which in the case of Colonial Agricultural Scholars one year would normally be spent in Trinidad. It is a matter for regret that, owing to circumstances arising from the world trade depression, the unified Colonial Agricultural Service, which had also been so strongly advocated in 1927 by the Committee of which the late Lord Lovat was Chairman, has so far failed to materialize; but when the proposals in this connection are revived the Imperial College should be in a position to play its part in making them effective*. To revert to the Committee of the Conference. They finally expressed the hope that every Government might find it possible to give substantial financial assistance to the College and that "in any instance where circumstances should preclude this being done, at the very least an annual contribution of a nominal amount will be forthcoming in recognition of the importance of the College in the development of Colonial Agriculture". Approval of the Committee's report was recorded by the Conference at a plenary meeting held in 1930, in the following minute: "In particular the Conference recognizes the importance of the Imperial College of Tropical Agriculture as the centre for post-graduate training in tropical agriculture for the Agricultural Services of the Colonial Empire. It recommends that those Colonial Governments which do not at present contribute towards its maintenance should be invited to give some financial assistance to the College as soon as a reliable forecast can be given as to its needs for the next five years." Then came the economic depression, and so acute was the financial crisis that the Colonial Office declined to invite the non-contributing Colonies to make even token contributions towards the maintenance of the College, whose staff is so ceaselessly working in the interests of the tropical parts of the Empire.

The question of finance has been a constant source of anxiety to the Governing Body. At the start contributions of one-half of one per cent. of their revenue made by the West Indian Colonies (Jamaica excepted) towards the cost of

* Colonial Agricultural Service. Report of a Committee appointed by the Secretary of State for the Colonies, Command Paper 3049. 1928.

maintenance were supplemented by a grant-in-aid of £15,000, spread over five years, from His Majesty's Government. The British Cotton Growing Association contributed £500 in the first year and has given the same amount annually ever since. In the second year the Empire Cotton Growing Corporation made the first of a series of annual grants of £500 which are still being maintained, and in 1926 it generously contributed jointly with the Empire Marketing Board and in equal moieties a capital sum of £42,000, of which £10,000 was earmarked to meet existing liabilities and the balance for new buildings and equipment. This brought the total of a special fund which Viscount Milner, and after his death Viscount Burnham, consented to raise to £87,872. The Empire Marketing Board has also been a generous benefactor of the College. From 1926-27 onwards it provided annual contributions at first to meet deficiencies and latterly in the form of block grants, but with increasing demands made upon the College, and the rapid development of its activities, the Governing Body found it impossible to balance the annual budget. In 1931 they were promised a block grant of £16,000 a year for five years from the Empire Marketing Fund, but when the world trade depression became acute the grant was cut to £14,400 and the prospect of its continuance appeared doubtful. A deputation, therefore, waited on Sir Philip Cunliffe-Lister on December 10, 1931, to explain to him the gravity of the situation. It was introduced by the Earl of Derby and included representatives of Cambridge University, the Empire Cotton Growing Corporation and the British Cotton Growing Association, besides the Governing Body, who declared that the difficulty of financing the College had become so acute as to threaten to interfere with the education and research proceeding at it. As a result the Empire Marketing Board undertook to provide an annual block maintenance grant of not less than £14,400 and not more than £16,000, according to the strength of its financial position, for each of the four years 1933 to 1936. But now the Empire Marketing Board has been thrown into the melting pot. The uncertainty is therefore greater than ever, and it can never be completely removed until the Imperial College of Tropical Agriculture has behind it a substantial endowment fund, for the creation of which there is pressing need. In 1932 the Governing Body received a welcome contribution of £32,000 towards such a fund from the Carnegie Corporation, and it will be a sad reflection on British enterprise if it is not supplemented by similar gifts from wealthy firms and individuals resident in this country and in the Dominions and Colonies, whose imagination must surely be stirred by the achievements of the College, past students of which are now promoting the development of agriculture on scientific lines throughout our far-flung Empire.

## WEST INDIAN NOTES.

*(Compiled by the Advisory Department, Imperial College of Tropical Agriculture.)*

The exports of green limes from Dominica shows a further serious decline from 7,494 barrels in 1932 to 4,023 barrels in 1933.

* * *

The 1934 arrowroot crop of St. Vincent is expected to be a record one and will amount probably from 26,000 to 27,000 barrels.

* * *

A recent report on the Nevis land settlement scheme indicates that steady progress is being made. The majority of the plots taken are well worked, the chief crops being sugar-cane, cotton and ground provisions.

* * *

Some interesting experiments are being carried out in Montserrat with various types of onions, including the ordinary Teneriffe, white Dhulia and Red Bombay. A fair quantity of Montserrat produced seed is also being tried for the first time.

* * *

Following on the recommendation of the Jamaica Fruit and Vegetable Conference some of the Islands propose to concentrate on producing tomatoes for the late Canadian season, more particularly during the months of April to June. The quantity of Empire grown tomatoes at that time of year is quite insufficient to meet the Canadian demand.

Increased areas have been planted in Sea Island cotton in Nevis and St. Vincent for the 1933-34 crop. The area planted is, however, within the limits agreed at the 1932 Cotton Conference. The 1933 cotton crop in Montserrat has now been reaped and yields above the average were obtained. From an area of 2,182 acres a yield of 486,683 lb. of lint was secured, most of which has been sold.

* * *

Withertip disease on limes which was suspected to be present in Montserrat as far back as 1927 is now reported on estates in the Leeward as well as the Windward districts. Antigua now remains one of the few Islands where this disease has not made its appearance. In Trinidad the heavy rejects due to withertip markings on green limes is a serious factor retarding the development of the green lime trade.

* * *

The total number of budded citrus plants delivered from the Government nurseries in St. Lucia up to the end of October exceeded 10,000. Citrus nurseries are to be established in the Mahaut Valley and in certain of the Leeward districts in the near future. In Dominica close on 29,000 budded citrus plants have been distributed from Government nurseries during the year up to the end of October.

# ROTATIONS IN THE TROPICS.

BY

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## Mixtures and Rotations.

It has been shown elsewhere that primitive systems of agriculture are noticeable generally for the number of crops which find a place in them. This is because in primitive communities, where communications are poor, each peasant has to grow all his own needs, and thus maintain himself as a self-supporting unit.

But the tendency in all industries to-day is towards specialisation, and agriculture is no exception, so that larger and larger areas are being devoted to pure cultures of single crops. Between these two extremes, lies the vast bulk of the agriculture of to-day, each farmer growing a greater or less diversity of crops, partly for sale and partly for consumption. This introduces the distinction between *food* and *money* crops, and it may be remarked that the ratio between these two, forms a rough test of the standard of any farming system. Where money crops preponderate the standard is high, where food crops predominate, farming will generally be found to be primitive. It is the exception nowadays for the farmer in England to eat bread from his own wheat or drink beer from his own barley, and he depends less on his own beef and pork than he did a century ago; he has developed his farming to the point where practically everything is grown for sale.

Not so primitive man; he still grows crops that will satisfy his needs—primarily, of course, food crops which will maintain life for his folk and his cattle or crops to meet his simple needs in the way of clothing—wool or cotton,—rope and, may be, building materials. As he progresses, his tastes become more exacting, and he cultivates various condiments, like chillies, oils like sesamum, and luxuries like sugar, instead of obtaining them from the jungle.

This wide variety of crops was, and is still in many cases, sown in various *mixtures*, for such is the easiest method, and where the crops are to be reaped singly, by hand, there is no grave objection. A mixture will take the utmost advantage of the soil and the season: thus there may be included crops which are tall and short, long term and short term, quickly developing and slowly developing, deep rooted and shallow rooted, climbing or upright. So whether the rains start well and peter out, or *vice versa*, the peasant obtains from his mixed crop as much as the season permits. Some crops, in particular those that start rather slowly, are rarely seen in pure culture: pigeon pea (*Cajanus indicus*) and perhaps groundnuts (*Arachis*) are examples. A typical continental area mixture may contain a millet and a pulse, a bast-fibre crop, cotton, chillies and a cucurbit. It is true that they will ripen at different times and so facilitate the spread of weeds, but in the dry weather usually experienced at harvest time, this is not a serious drawback.

Such mixtures may persist even when crops are drilled, and when rotations are adopted. In the groundnut area of Madras, it is a common practice to dibble groundnuts in a crop of millet (*Pennisetum*) at the time when the latter crop receives its first weeding, when it is 18 inches to 24 inches high. Again, in the black soils of the dry plateau of Central India, a mixture of cotton (*G. herbaceum*) and Italian millet (*Setaria italica*) which covers large areas, is neatly drilled, two rows of the millet 12 inches apart being put in to one of cotton: when cotton is sown as a pure crop the lines are only 2 ft. 6 ins. apart.

Such a system of growing crops in mixtures, common throughout the tropics, is occasionally found, in special cases, in very highly developed farming systems. Where it is desirable to protect a newly planted crop, either from the wind or from the excessive heat of the sun, quickly growing shelter crops will be planted along with the more valuable staple. Such a practice is illustrated by the planting of bananas or root-crops to shade young cocoa.

Again, where a crop is grown for fodder, a mixture, more especially a mixture of a cereal and a pulse, will often give a heavier yield than either would singly, a trailing legume supported by a stiff cereal, for instance will produce a larger leaf surface. The resulting composite fodder, moreover, will tend to be a better balanced ration than either separately.

There may be yet other reasons for growing mixed crops. A mixture of long and short term rices is sometimes grown in Southern India. When the early crop is ripe, the whole is reaped, and with further irrigation, the shoots of the immature rice sprout again and produce what is virtually a second crop, though in actual fact the peasants have been able, so far successfully, to maintain that it is really a single crop, and pay only single water-rate!

The benefits of mixtures may be summarised by saying they are those ordinarily attending crop diversification. The possibility of crop failure is diminished, for loss due to insects, for instance, will generally be confined to one staple. A mixture tends to distribute work more evenly throughout the season, and level out the peaks which occur at certain seasons in one-crop areas. Finally it takes the best advantage of the soil and the weather in any one season.

The real disadvantage of sowing mixed crops lies in the expense of harvesting them, because if they have to be kept separate, this will have to be done by hand. Modern harvesting machinery can only deal with pure crops, but even before

the reaper and binder was used, the sickle and still more the scythe, found it a great advantage to deal with pure rather than with mixed crops.

And so is evolved the great modification, whereby the variety of crops grown is not necessarily reduced, but each is grown in a separate plot under a pure stand. This modification was independent of the gradual change over from food to money crops: the English farmer of the last century was largely self supporting, but yet he followed a strict system of *rotation*. This was the name given to the new system, for it became evident, that, as soon as the farmer grew his staples in separate plots or fields, the question of the *order* in which he was going to grow them, became of the first importance.

The advantages of rotation (1) soon became evident, for as experience accumulated, it was found that certain crops were *restorative* and served as good preceders for any or only for certain crops, while others could be used for smothering weeds. Increasing knowledge of the different demands made on the soil by different crops showed that some drew more heavily than others on particular constituents in the soil, and that by growing them in rotation there was less risk of any one constituent being unduly depleted. It was found that the risk of insect and fungus attack, which was increased by the cultivation of superior and perhaps less resistant types, was reduced, and the damage in any case minimised, by a rotational system of cropping. And so the system of growing crops pure, and in a definite rotation or order has become the basis of nearly all modern husbandry. There are exceptions, of course; rice (*Oryza sativa*), the third most important food crop in the world, is almost universally grown year after year on the same land with no other rotation crop, while Trinidad presents a good instance of a successful cane growing industry carried on in defiance of the ordinary rules governing good farming. But these are exceptions, and some form of rotation is almost universal.

It is, of course, understood that no rotation is unalterable, and the skilful farmer will modify his cropping to suit his particular needs, but the adoption of a definite scheme is of such assistance in systematising the work of the farm, already liable to be thrown out by the vagaries of the weather, that in most areas a more or less regular system is found which is adhered to, unless there is reason to alter it. Such a system is the result of experience and is not lightly to be set aside, but changing economic conditions, or the introduction of a new crop, such as cotton, necessitate alterations. These must only be made after deciding upon the crops to be grown, the relative quantities in which they are to be grown, and the sequence they shall follow. The first consideration is, of course, the provision of food for the owner and for his cattle, either as cereals, legumes, root crops, or any combination of these. Next come the money crops which will enable him to pay his taxes, and purchase salt, lamp oil and other simple necessaries. The last consideration, the *sequence* in which the crops shall be taken, can only be settled after many years of experience. It will be found that there are crops which do better when grown in a certain order; or that one succession of planting gives more facility for preparing or cleaning the land than another, or is better from the point of view of stifling weed-growth. Bound up with this question of the best order in which to grow the crops, is the problem of the best place in the rotation to apply the scanty stock of manure, and to what extent it will be necessary to supplement it by growing restorative crops. Even then, outside considerations may cause a complete modification; for instance, if a new road is constructed in the neighbourhood, it may become profitable to grow an area of soft canes, to be sold for chewing, either to the passers-by, or for transport on the road to some populous centre. The question of aspect is not of so much importance in the tropics, as in temperate regions, where the sun is lower down in the sky, but shelter, especially from drying winds, will often determine the most profitable crops to grow.

Bearing in mind all these considerations, what actual rotations are found? The simplest are based on a fallow, and the most elementary type will be Crop, Fallow and then Crop again: or there may be two Crops between the Fallows. An improvement on this is the introduction of a legume as a restorative crop, *e.g.*:

Cereal (*Sorghum*).
Legume (*Cicer arietinum*).
Fallow.

This is a rotation which occupies many thousands of acres of the dry black cotton soil in Southern India, and is similar to the old English rotation of (i) Wheat, (ii) Beans, (iii) Fallow. This may seem elementary, but even these elementary rules have been broken, as, for instance, in growing maize in Southern Rhodesia, where the continued cropping of the land with maize has reduced the crop to unprofitable yields. An excellent experiment at the Salisbury Station (2) drives this point home very strongly:

**Salisbury Experimental Station—Maize Rotation Experiment.**

| | Crop. | Av. yield for years 1913-1929. | Acreage under maize out of 1000 acres. | Total bags reaped (of 200 lb.) | Cost per bag in shillings. |
|---|---|---|---|---|---|
| | | lb. per acre. | | | |
| 1 | Maize—every year .... | 1,188 | 1,000 | 5,940 | 5.3 |
| 2 | Maize and Fallow .... | 2,178 | 500 | 5,445 | 4.1 |
| 3 | Maize, Stizolobium, Oats. (No manure) | 3,044 | 333 | 5,073 | 1.9 |

More convincing evidence of the value of and the necessity for properly balanced, rotational systems of cropping, it would be difficult to find.

It is impossible, of course, to notice more than a few representative rotations which are adopted in the tropics, and it must be remembered that, as land is frequently cropped more than once a year, when conditions are favourable, it is better to describe rotations as three-course, four-course and so on, instead of three-year, four-year. In the drier areas where year and course are the same, a typical rotation is :—

| | | |
|---|---|---|
| (i) Sorghum | | (i) Sorghum. |
| (ii) Cotton | or | (ii) Cotton. |
| | | (iii) Pulse. |

With little manure produced, and that mostly burnt, it would appear an exhausting rotation, but a compulsory fallowing from the failure of the rains holds the balance.

A rotation from Iraq illustrates double cropping, for it comprises three crops in two years, all of which are irrigated.

| | | |
|---|---|---|
| (i) Cotton | March-October | Two years. |
| (ii) Cereal | November-May | |
| (iii) Legume (Berseem) | June-March | |

Nigeria (3) provides a somewhat similar rotation but with a prolonged fallow period during which the land recovers its fertility. It may be described as a modified system of shifting cultivation, and illustrates also the practice of starting a crop before the preceding one is off the land, thus, as far as possible, always keeping the land covered, a point of great importance in tropical regions of heavy rainfall.

| | |
|---|---|
| (i) Maize .... .... | ....September-February. |
| (ii) Yams planted in the Maize | November-September. |
| (iii) Maize planted through Yams .... | ....March-August. |
| Cotton planted through Yams and Maize | ....August-February. |
| (iv) Maize .... .... | ....March-August. |
| (v) Cassava planted through Maize .... | ....May-January. |
| (vi) Fallow for a number of years. | |

A possible improvement on this long fallow, where conditions are favourable, and there is a local demand for firewood, as in the vicinity of a large town, is to take a crop of *Casuarina equisetifolia* (4), which will remain down for ten years.

Lastly, as an illustration of the construction of a rotation and the modifications which have been made in it as a result of experience, may be quoted a rotation initiated at the Imperial College of Tropical Agriculture to test one aspect of the problem of settling the peasant on the land, and checking the practice of shifting cultivation. It was postulated that 'tsetse' would prohibit the keeping of cattle, so recourse was necessarily had to restorative crops to maintain fertility :—

| | | |
|---|---|---|
| (i) Stizolobium | followed by Maize. | |
| (ii) Soya Bean | do. | Tobacco, Cotton, Pigeon Pea. |
| (iii) Stizolobium | do. | Sweet Potatoes. |
| (iv) Maize | do. | Cowpeas. |

This includes in the eight crops which are taken in four years, two grain crops, one early and one late; one and a third pulse crops, and one root crop, *i.e.*, over half the area to food crops; one and two-thirds purely industrial crops, on the understanding that in favourable seasons a good deal of the food crop would be sold; and two restorative crops.

The experience of the first three years have shown that the land cannot carry as much as this, and with the addition of potash and phosphoric acid, the experiment is now testing the maintenance of nitrogen fertility only. Secondly, the scheme implies fairly long periods when the land is left uncovered, and this is most wasteful of fertility, as, under the heavy rainfall which is experienced, the land gets badly leached. Arrangements are now made that whenever there is a period not less than a month before the next regular crop is due to be sown, and moisture is in the ground, a cover crop of *Phaseolus aureus*, or *Crotalaria juncea* is to be sown.

Lastly, rotations in the tropics are in general, more elastic than is customary in temperate climates, especially where the rainfall is plentiful. There is not the same difficulty about the recruitment of casual labour, and the farmer has a wider choice of crops.

Leppan (5) in comparing the somewhat restricted cropping practised in South Africa with the variety grown by the Bombay peasant, professes himself much struck with the way in which the latter modifies his system of cropping in accordance with the exigencies of the season.

**References.**

(1) Symposium on Crop Rotation. *Jl. Amer. Soc. Agron.*, 19, 565.
(2) *Rhodesian Agricultural Jl.*, 27, 470. [The figures have been recalculated.]
(3) "West African Agriculture." Faulkner and Mackie.
(4) Casuarina planting in an arable rotation. *Tropical Agriculturist*, 62, 56.
(5) Leppan : "The Agricultural Development of Arid Regions."

## REVIEW.

MINERALS AND THE MICROSCOPE.

By H. G. Smith. *T. Murby & Co.*, London, Third Edition, 1933, 5*s.*, pp. 124.

The object of this book is to help the beginner over his initial difficulties in the study of petrology, which is the science of rocks. Rock study is essential to a thorough understanding of the origin and natural history of tropical soils. Particularly in humid tropical countries, igneous rocks frequently give rise to fertile soils, whereas, in temperate regions, igneous rocks are seldom sufficiently weathered to yield soils of agricultural importance. Hence, in academic courses on tropical soils, petrology should be taught as a fundamental subject. A book such as this should therefore be useful in this connection, since it adequately deals with the identification and chief characters of the commoner rock-forming materials as displayed in thin sections for examination under the microscope.

F. H.

## CHEMICAL NOTES.

*Compiled by the College Department of Chemistry and Soil Science.*

**Suitable Soil Media for Cacao-Seedling Growth.**

The Effect of Different Soil Media on the Rate of Growth of Cacao Seedlings. Pedro Z. Madrid *Philippine Agriculturist*, 1933, XXII, 3, p. 172.

This paper describes an investigation carried out at the College of Agriculture, University of the Philippines, on the effect of different soil media on the rate of growth of cacao seedlings. In the preparation of the different media, the following materials were used:—(*a*) forest soil, (*b*) garden soil, (*c*) sand, (*d*) compost, (*e*) chicken manure, (*f*) horse manure. By mixing these materials in varying proportions, 14 different media were prepared and tested.

The results show that the different soil media produced very distinct effects on the growth of the seedlings, as measured by number of leaves produced, elongation of the stem, and increase in diameter of the stem. A soil medium consisting of a combination of equal proportions of garden soil and compost gave the best results for rapid growth and development. Cacao seedlings planted in this mixture were ready for transplanting in about three to four months after the time of sowing.

A direct relationship between the chemical constituents of the different soil media tested and the rate of growth of the cacao seedling was demonstrated; for example, a very high degree of correlation was established between *total phosphate* content of the different media and the *growth of leaves and stems*, and a lesser, though still high degree of correlation between *total nitrogen* content and the growth of leaves and stems. There was no significant correlation, however, between the *total potash* content and growth.

* * *

**Improvement of Beef Cattle in Australia.**

If, as predicted by Dr. J. B. Orr, Australia is to become "the stock farm of the Empire", one of its urgent needs is the improvement of the beef cattle breeds in the northern tropical parts of Queensland, North Australia and Western Australia. The handicaps to British breeds are sparse fodder and prevalence of ticks and tick fever. The success reported to have followed the introduction of Brahman (Zebu) strains into herds in poorly grassed, tick-infested territories bordering on the Gulf of Mexico induced the Australian Council for Scientific and Industrial Research in 1931 to make a close investigation of the actual position. As a result, it has for some time strongly advocated experimental breeding in Australia to evolve a suitable cross for the north between British and Brahman cattle. Lack of funds prevented immediate action, but four pastoral companies have now made sufficient money available to ensure a thorough test of the possibilities of the cross. An officer of the Council is in the United States selecting suitable animals (probably eight bulls and two cows) which will be shipped to Australia and, after compliance with exacting quarantine conditions, will be divided amongst the properties of the companies, which at present carry chiefly shorthorns and Herefords. All breeding and culling will be under the sole supervision and control of the Commonwealth Council for Scientific and Industrial Research. Many years will be required for the evolution of an animal suitable for northern tropical conditions but success, if attained, will be of considerable importance to many parts of the Empire.—(*Nature*, Vol. CXXXI, p. 576.)

* * *

**Bulkiness of Food as a Factor in Poultry Feeding.**

A factor in poultry feeding to which some importance has been attached in recent years is that of bulkiness of the food supplied. A certain amount of food is used up by the bird in living—the *maintenance ration*—and it is only the amount over and above this maintenance ration that can be used by the bird for producing eggs. Thus the number of eggs produced by a hen will depend partly on the amount of food actually eaten in excess of the maintenance ration. A limiting factor will be the physical capacity of the bird to absorb the food available—in other words it will depend to some extent on the bulkiness of the food, which may be important in the case of small rapidly growing animals.

After considering the various factors, the authors select two mashes which they find suitable. They are as follows:—

(*a*) Growing and Rearing Mash.
- 6 parts home-milled bran.
- 1 part fine middlings.
- 1 part oatmeal.
- 8 parts corn (maize or wheat).

(*b*) Laying Mash.
- 2 parts bran.
- 4 parts coarse middlings.
- 2 parts maize meal.
- 1 part Sussex ground oats.
- 1 part meat and bone meal.
- 10 parts maize.

Feed three parts of this mash to one part of corn. (Shaw and Fisher, *J. Ministry of Agric.*, Vol. XL, No. 4, p. 327.)

* * *

**Record Yield in Hawaii.**

What is claimed to be the world's record sugar production is reported from Hawaii, where in the plantation of the Hawaiian Sugar Company, in Kauai, a patch of nine acres averaged 186 tons of cane per acre, yielding slightly over 21 tons of commercial raw sugar per acre, or just under nine tons of cane to one of sugar. The variety grown was H 109. The patch was part of a field that had been fallow for a number of years. Besides this, the same company harvested two other fields in the same area which averaged 137 tons of cane, yielding more than 16 tons of sugar; these were planted with H 109 and POJ 2878.—(*Inter. Sugar Jour.* Vol. XXXIV, No. 404, p. 319.)

## TREND OF THE MARKETS.

*[The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.]*

SUGAR:—Prices on the Home Market have ranged as follows (c.i.f. per cwt.):—

| | *Foreign.* | | *Preferential.* | |
|---|---|---|---|---|
| | *s.* | *d.* | *s.* | *d.* |
| 30th November .... | 4 | 7½ | 9 | 4½ |
| 7th December .... | 4 | 7½ | 9 | 3 |
| 14th December .... | 4 | 7½ | 9 | 3 |
| 21st December .... | 4 | 7½ | 9 | 1½ |
| 28th December .... | 4 | 5¼ | 9 | 3 |
| 4th January .... | 4 | 6¾ | 9 | 6 |
| 11th January .... | 4 | 7½ | 9 | 6¾ |
| (12*th Jan.*, 1933) .... | 5 | 0 | 9 | 9 |

Although there was a slight improvement in the position of the article early in December the market has since ruled very inactive while the volume of business has been small. The uncertainty as to the Cuban policy and the present economic and political unsettlement throughout the World have generally proved detrimental to market activity. Steady progress has, however, been made in narrowing the margin between sugar supplies and requirements. In this respect production in 1932-33 shows, according to Dr. Mikush, a reduction from the peak figure of nearly 3½ million tons while consumption indicates that the rapid decline since 1928-29 has at last been halted.

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows:—

| | *d.* |
|---|---|
| 29th November .... .... | 4 3-16 |
| 6th December .... .... | 4 11-32 |
| 13th December .... .... | 4 3-16 |
| 20th December .... .... | 4 5-32 |
| 27th December .... .... | 4 3-16 |
| 4th January .... .... | 4 1-4 |
| 10th January .... .... | 4 3-4 |
| (11*th Jan.*, 1933) .... .... | 2 7-16 |

The trend of prices has again been affected by conflicting reports and rumours regarding the progress of the restriction negotiations which are proceeding in Batavia. It is understood that differences of opinion have arisen between Holland and Java regarding proposals for the regulation of exports by a Quota System. Total consumption of rubber in America up to November 1933 was 374,179 tons which compares with 296,131 tons in 1932 and 327,578 tons in 1931.

* * *

COCOA.—There has been a better prevailing tone for cocoa on the New York Exchange, no doubt due to reports of short crops in most producing countries. Prices have hardened and speculators are now showing anxiety to cover commitments. Manufacturers still maintain, however, that they are not interested as they have ample stocks.—(*By Courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*)

LIME PRODUCTS.—*Lime Oil.*—Handpressed is unchanged with sellers at 35*s. ex* wharf London. There are sellers of Distilled, which is slow of sale, at 27*s. ex* wharf. *Lime Juice.* There are buyers of Concentrated at £4 10*s.* Small sales of Raw have been made at 2*s.* per gallon c.i.f. for good Jamaica.—(*West India Committee Circular*, 21st December.)

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association:—

| | *American Mid.* | *Egyptian F.G.F. Sakel.* |
|---|---|---|
| 24th November .... | 5.09 | 7.01 |
| 1st December .... | 5.15 | 7.14 |
| 8th December .... | 5.25 | 7.10 |
| 15th December .... | 5.25 | 7.16 |
| 22nd December .... | 5.25 | 7.31 |
| 29th December .... | 5.32 | — |
| 5th January .... | 5.39 | — |
| 12th January .... | 5.83 | — |
| (13*th Jan.*, 1933) .... | 5.30 | 7.53 |

Prices have fluctuated narrowly, but have shown a steady tendency. The present uncertainty regarding American monetary policy is holding up business in every direction. The statistical situation is, however stronger than last season. West Indian continues quiet with enquiry chiefly confined to stained cotton at 7d. to 8d.

* * *

GRAPEFRUIT.—The average prices ruling in Covent Garden for the week ending December 16th were:

| | *s.* | *d.* | | *s.* | *d.* |
|---|---|---|---|---|---|
| Trinidad .. .. | 16 | 0 | to | 18 | 0 |
| Jamaica .. .. | 10 | 0 | ,, | 12 | 0 |
| Palestine .. .. | 12 | 0 | ,, | 15 | 0 |
| United States .. | 12 | 0 | ,, | 18 | 0 |
| Puerto Rico .. | 10 | 0 | ,, | 14 | 0 |
| Cuba .. .. | 10 | 0 | ,, | 15 | 0 |
| Honduras .. | 10 | 0 | ,, | 16 | 0 |

(*West India Committee Circular*, 21st December.)

* * *

BANANAS:—Owing to the extremely cold weather, the demand has been poor and prices for all sorts are lower on the fortnight. Both the Jamaica Producers and Elders & Fyffes, Ltd., have again lowered their prices to wholesalers and now quote £18 5*s.* per ton delivered London and £18 nearest station Provinces. Brazilians are £1 per ton lower at £18 delivered nearest Station.

The total imports into the United Kingdom for the eleven months to November 30th (with the figures for Jamaica in brackets) were 14,934,341 bunches (6,250,258) as compared with 16,305,773 (10,361,043) and 15,018,118 (6,286,193) for the same periods in 1932 and 1931 respectively. (*West India Committee Circular*, 21st December.)